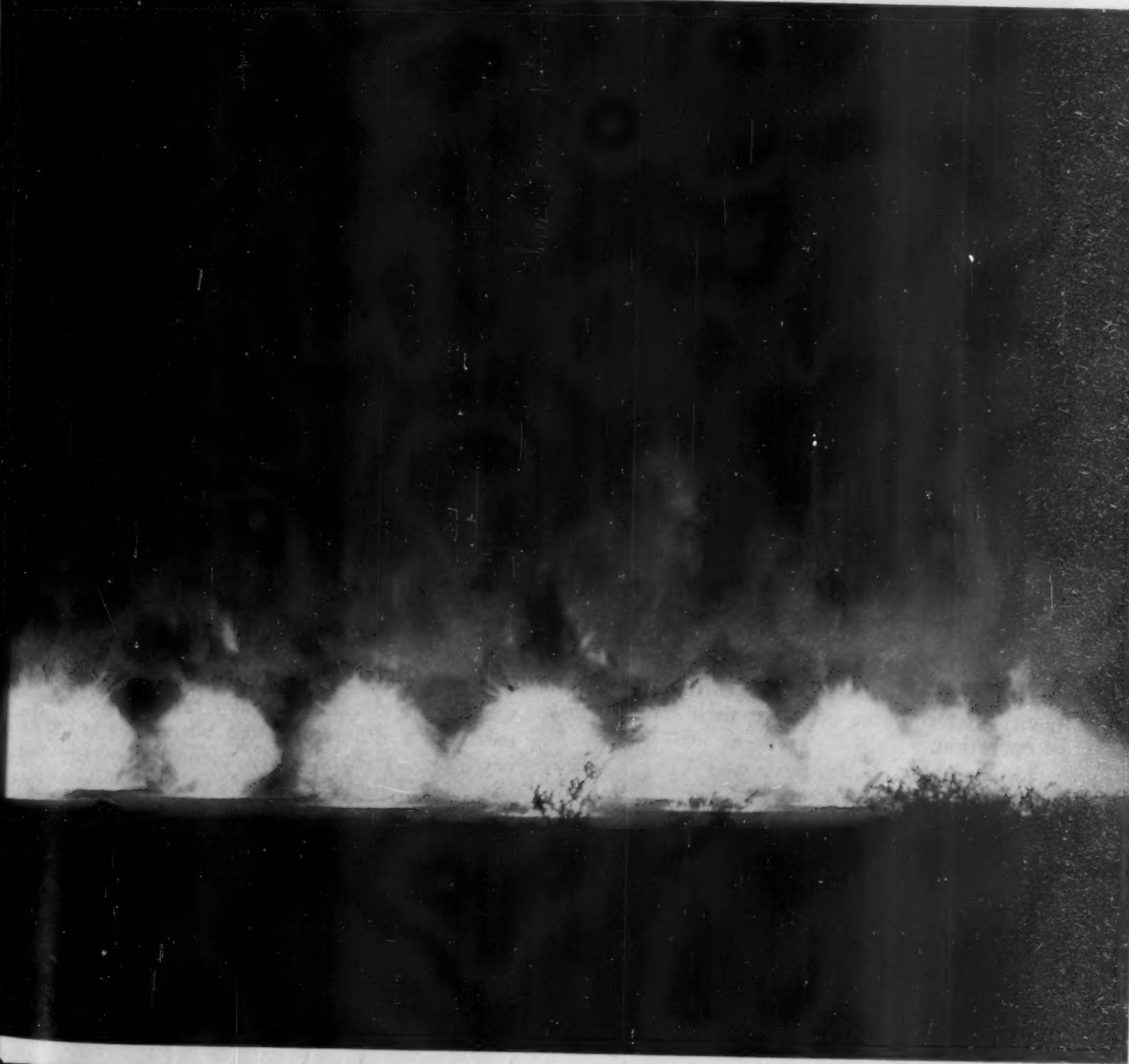


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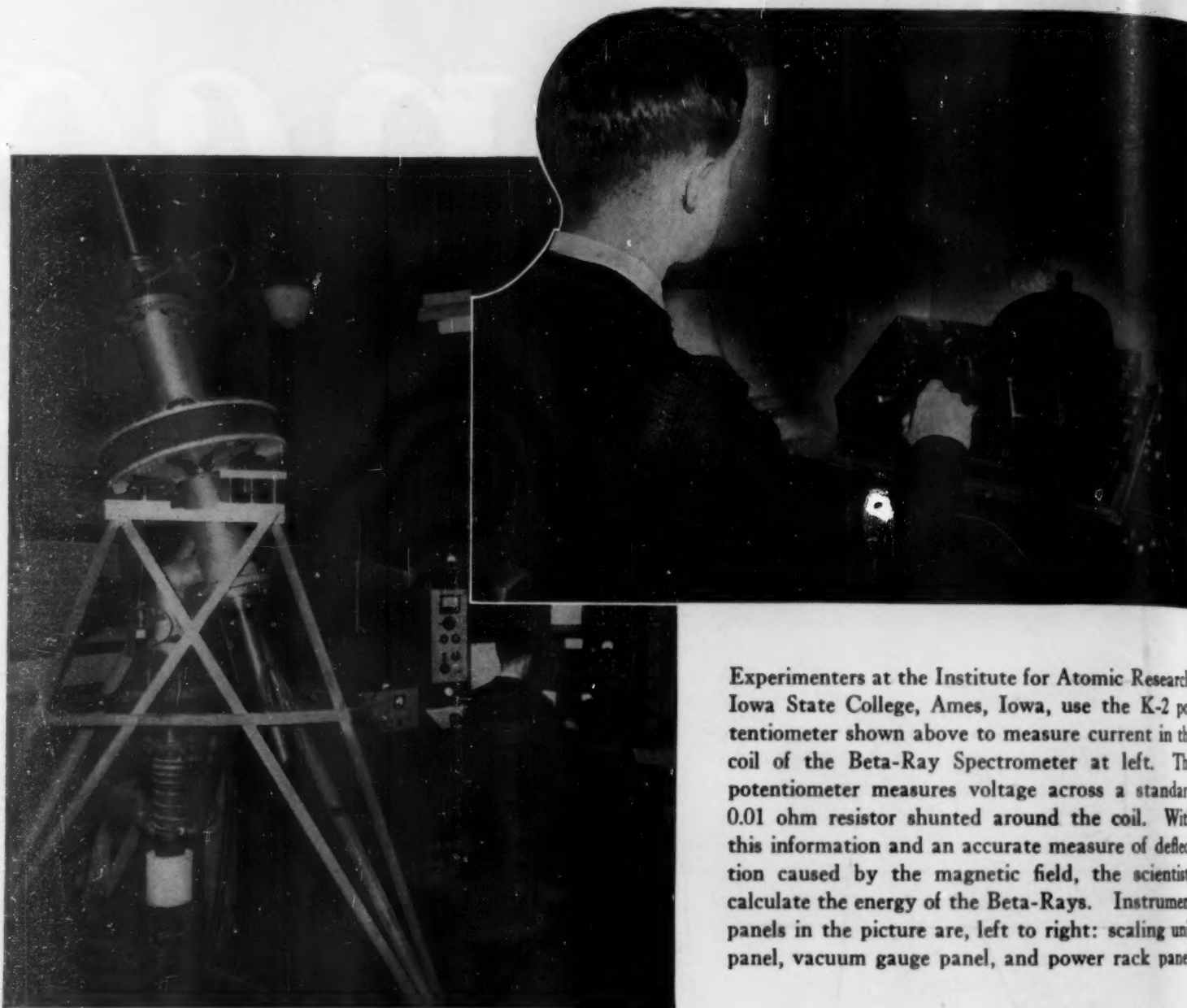
November 19, 1948

Science



Seismic Exploration—A New Method

(See page 372)



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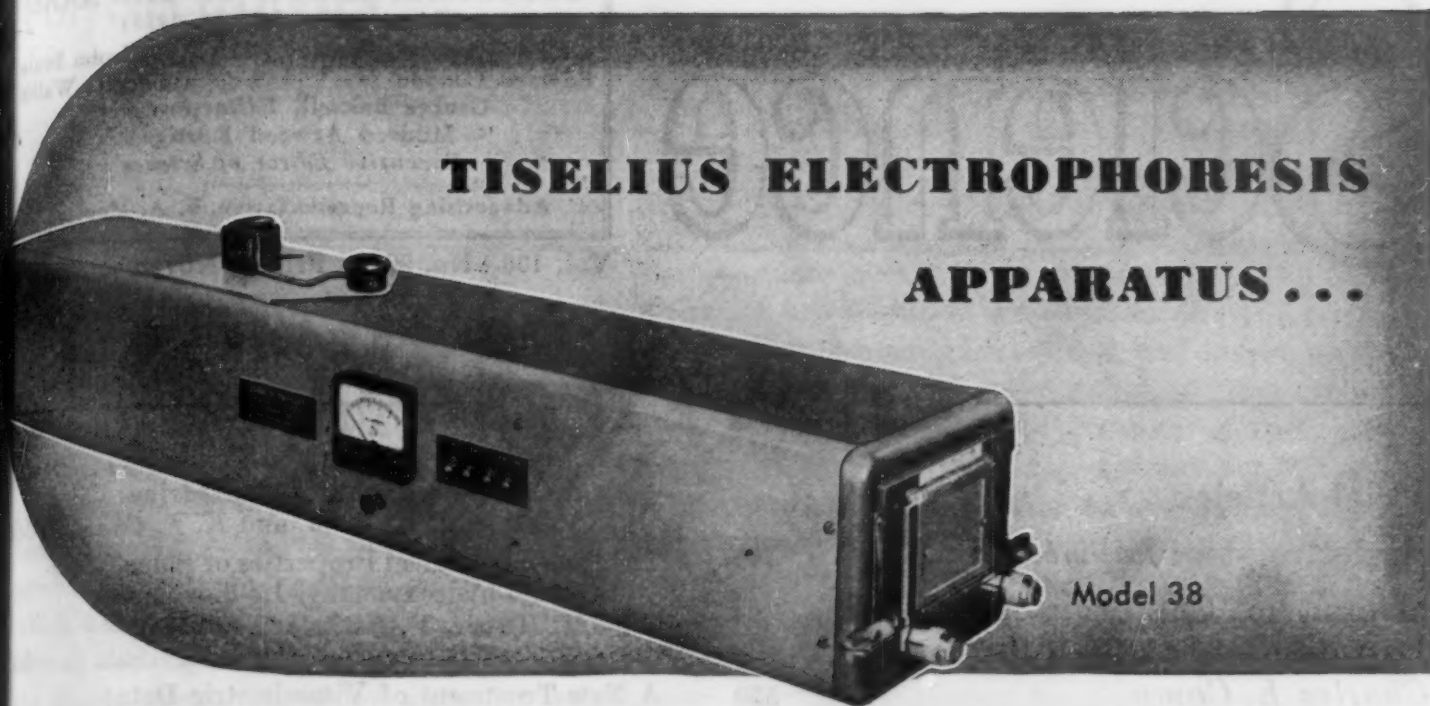


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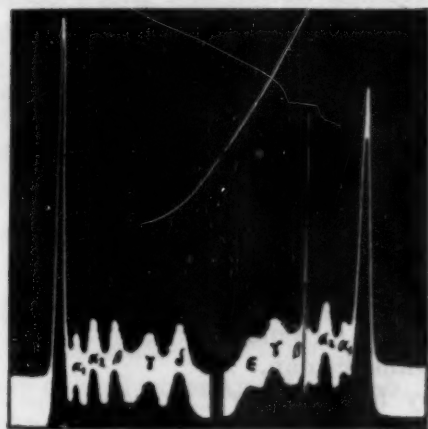
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SCIENCE, November 19, 1948, Vol. 108

Polyelectrolytes

Raymond M. Fuoss

Sterling Chemistry Laboratory, Yale University

"POLYELECTROLYTES" is a term which has been coined to describe substances of high molecular weight which are simultaneously electrolytes. Within the scope of this definition are a number of possible subclasses. According to source, we have, on the one hand, the naturally-occurring polyelectrolytes such as proteins and polysaccharides and, on the other, the synthetic materials which will be described shortly. From the point of view of electrolytic behavior, polyelectrolytes, just like the simple electrolytes of low molecular weight, may be either weak or strong. Very briefly, a weak electrolyte is one for which there exists a neutral molecule, held together by electronic bonds, and which can dissociate into ions; a strong electrolyte is one for which only ions exist. Acetic acid and sodium chloride are, respectively, familiar examples of the two classes. The former is present in liquid acetic acid mostly as the electrically neutral $\text{CH}_3 \cdot \text{CO}_2\text{H}$ molecule, which in water or other basic solvents can dissociate into a negative acetate ion and a positive hydrogen ion; this dissociation involves an electron rearrangement. The latter, however, exists as a lattice of positive sodium ions and negative chloride ions in the crystal; on solution, these ions become solvated and separate, retaining the charges which characterize them. No dissociation, in the sense of breaking electron bonds, is involved; only electrostatic Coulomb forces need to be considered.

The importance of an understanding of the behavior of proteins and polysaccharides need not be emphasized—these are essential building blocks of all living organisms. The biochemist, who might be described as one who studies the chemistry of substances of natural origin, labors under a number of handicaps which do not interfere with his colleague, the chemist, who works with synthetic compounds. The biochemist necessarily must begin his work with substances of unknown chemical structure; before he can even begin

a breakdown of the molecule to determine its structure, he must demonstrate that he has succeeded in separating a chemical individual from the biological source material. The chemistry of these compounds is determined by the source and not by the experimenter. Furthermore, the materials are often chemically or biologically unstable and must be handled with care under sterile conditions at low temperatures. Finally, since life processes are planned around water as the solvent medium, nature has finally evolved as her most important compounds substances which are water soluble but insoluble in most other liquids. This limitation is a serious barrier to a general understanding of the physical chemistry of polyelectrolytic materials, because many of their properties are determined by the interaction of electrical forces between ions, and the intensity of these forces depends on the dielectric constant of the solvent. Obviously, unless we can control this variable, we are unable to investigate its effect.

In recent years polymer chemists have shown how it is possible to synthesize compounds of high molecular weight by a variety of methods from known compounds (monomers) of low molecular weight. Familiar examples include polystyrene, synthetic rubber, and Nylon. These and other linear polymers consist essentially of long chains of atoms (usually carbon, oxygen, and nitrogen) which are held together by stable electronic bonds and to which are attached, at regular intervals, side groups of one sort or another which impart special chemical and physical properties to the polymer. If the monomer can react with only two other molecules, the resulting macromolecule is necessarily a chain, which usually assumes a curled-up configuration; if the monomer can react with three or more other molecules, networks and lattices of very high molecular weight result. Bakelite and vulcanized rubber are examples of the latter types. An additional controllable variable is at the disposal of the synthetic chemist: by polymerizing mixtures of monomers, copolymers can be made in which different chemical units follow each other in the resulting chain molecule in sequences which are approximately predictable. We thus have the techniques available for the synthesis of new compounds of high molecular weight and, within reasonable limits at least, we can

This paper was presented in the Symposium on High Polymers, held on September 14, in Washington, D. C., during the Centennial Celebration of the AAAS. The results reported are based on experiments made by W. S. Albrink, G. I. Cathers, V. Chu, D. Edelson, W. N. Maclay, and U. P. Strauss, at the Sterling Chemistry Laboratory, Yale University, under Project NR 054-002, Office of Naval Research.

design and make molecules with properties especially desirable for a given purpose.

SYNTHESIS

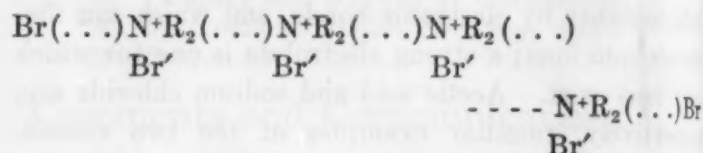
As has been suggested by the foregoing introductory remarks, the tools of the polymer chemist can be applied to the problem of polyelectrolytes. All that is required is the synthesis of electrolytes which have high molecular weight and known structure. We may then study their properties and learn how these depend on concentration, temperature, dielectric constant, and structure, and how they are affected by the presence of other chemical compounds of low and high molecular weight. A much wider range of variables is obviously available than is offered by naturally-occurring substances, and we may hope that eventually some of the problems of the biochemist will be reduced to special problems in a broader field—that of polyelectrolytes in general. It should, of course, be emphasized that the similarity sought between the natural and the synthetic polyelectrolytes is electrical rather than chemical. We may, for instance, never learn the detailed sequence of amino acids in a protein molecule, but we may hope to synthesize a molecule which will be its electrical analogue. In other words, our goal is not the ambitious one of duplicating nature's products in detail, but the more modest one of making models whose electrochemical behavior will resemble that of the biochemical substances. We may, then, be able to extrapolate from the known to the unknown.

When possible in a research program, it is usually preferable to start with simple systems and gradually work up to more complicated ones. As our initial problem, therefore, we have been investigating strong polyelectrolytes of several kinds. Proteins owe their electrical properties to the presence of amino groups and carboxyl groups, both of which give rise to weak electrolytes. As has already been mentioned, a discussion of weak electrolytes is complicated by the fact that dissociative equilibria must be considered as well as the effects of interionic Coulomb forces, whereas with strong electrolytes only electrostatic forces need to be taken into account.

Three examples of synthetic polyelectrolytes will be described; all are based on the reaction between alkyl halides and tertiary amines. In a tertiary amine, such as trimethylamine, 3 of the 5 valence electrons of nitrogen are paired with electrons from the carbon atoms of the methyl, ethyl, or other alkyl group. We might indicate the structure by $R_3N:$, where R stands for a methyl group and the colon indicates the remaining two electrons of the nitrogen. If an alkyl halide—for example, methyl bromide—

comes in contact with the amine, we may write the resulting reaction formally as an addition of the methyl group to the pair of electrons to give a quaternary ammonium ion, R_4N^+ , a structure with a net positive charge. Simultaneously, the bromine atom of the alkyl halide becomes a negatively charged bromide ion, Br^- , because the bromine nucleus is now surrounded by a swarm of electrons containing one negative charge in excess of the positive nuclear charge of the bromine. In other words, two electrically neutral substances have reacted by electron rearrangement to form two charged ions. The resulting compound, tetramethylammonium bromide, is a typical strong electrolyte which resembles sodium chloride in many of its properties.

Now suppose we have a molecule which contains two tertiary amino groups, one at each end, such as $R_2N(\dots)NR_2$, and allow it to react with a dihalide, $Br(\dots)Br$, with, say, bromine atoms at each end. By repetition of the simple reaction described above we obtain a chain electrolyte:



In this compound all of the nitrogen atoms have become centers of positive charge, which are tied together by the carbon atoms symbolically indicated by (\dots) . The bromide ions are small, negatively charged units which, in a solvent medium, are free to swim around within the coil of the polymeric chain or in the solvent medium between individual polymeric ions. A similar compound is often obtained if one attempts to prepare a molecule with a halogen atom at one end and an amino-nitrogen at the other. Meisenheimer and Marvel have both described examples of this sort.

We may also make polyelectrolytes by first synthesizing a chain molecule which contains tertiary nitrogen and then adding alkyl halide to the resulting compound. For example, condensation of succinic anhydride and methyl-diethanol amine gives a polyester, in which tertiary nitrogens are simultaneously chain atoms. Subsequent addition of methyl bromide gives the desired polyelectrolyte. By varying the number of neutral atoms between the nitrogen atoms in both this and the preceding compound, it is possible to make chain electrolytes in which the charges appear at different but known spacings along the chain.

Vinylpyridine offers the possibility of the synthesis of polyelectrolytes of somewhat different type. Vinylpyridine is superficially similar to the familiar styrene in that a vinyl group is attached to a ring of 6 atoms, and, just as in styrene, the vinyl groups will

polymerize to form long chains, the rings being appended to every other carbon atom of the chain. But there is a significant difference between the benzene ring in polystyrene and the pyridine ring in polyvinylpyridine: the latter contains a nitrogen atom which will again add alkyl halide to form a strong electrolyte. The positive pyridonium ions are in this case not part of the polymer chain but are attached to it by carbon-carbon bonds. Here we may vary the spacing of the charges by copolymerizing a mixture of vinylpyridine and styrene; on treatment with alkyl halide, addition will naturally occur only at the pyridine groups. And we can make chains which have, on an average, 1 ion to 10 chain atoms, 1 ion to 100 chain atoms, or whatever ratio we choose.

CONTRAST WITH SIMPLE ELECTROLYTES AND NEUTRAL POLYMERS

All of these strong polyelectrolytes possess one fundamental difference when contrasted with ordinary strong electrolytes like salt and hydrochloric acid. In the latter, both positive and negative ions are free, in the sense that they are capable of independent relative motion. In solution, we have (almost) a uniform distribution of positive and negative ions; by this, we mean that any microscopic exploratory element of volume would encounter, on an average, equal numbers of cations and anions as we move it through the solution. As we dilute such a solution, the average relative distances between all charges will increase. Not so, however, in the case of the polyelectrolytes. In the examples described above the positive ions are bound to the polymer chain. If we imagined an extremely dilute solution, the negative ions could diffuse away from the positive polyion, but the individual positive charges could, under the influence of their mutual repulsion, move apart only until the chain reached its maximum extension, after which further separation would become impossible. Consequently, the ionic distribution in a solution of polyelectrolyte is markedly different from that in one of ordinary electrolyte: instead of a uniform distribution of positive and negative ions, we will find positive charges in clusters, separated by solvent which contains only negative ions (except for possible impurities). The distribution of negative ions in the space between the polycations will not be spatially uniform. Due to the high concentration of charge in the region of the polymeric ions, bromide ions will be drawn into their vicinity by electrostatic attraction and will not act at all like the relatively free bromide ions in a solution of sodium bromide.

The geometrical configuration of the polyion will also be quite different from that of a neutral polymer

molecule such as polystyrene, as a consequence of electrostatic forces. In very dilute solutions we would expect a rather extended configuration, as has already been mentioned. As concentration increases and bromide ions are drawn into the sphere of the polyion, internal repulsions will be compensated, and the normal tendency of the chain to curl up will appear, possibly enhanced by interionic attraction of the sort which stabilizes a salt crystal.

Let us now turn to a consideration of the observed properties of the synthetic polyelectrolytes in solution.

VISCOSITY

Perhaps the most striking property of these compounds is the high viscosity which they impart to a liquid. For example, an alcoholic solution containing only 7% of the butyl bromide addition product of polyvinylpyridine is 10 times as viscous as alcohol, and a 1% solution of a similar compound of lower molecular weight in water has over three times the viscosity of water at the same temperature. Polymers in general are known to increase the viscosity of solvents, and valuable information concerning the shape and size of polymer molecules may be deduced from the viscosity curves. The polyelectrolytes differ from the neutral polymers in that the magnitude of the viscosity increment is enormously larger and the shape of the curves is markedly different. The shape of a curve is the visual representation of the underlying mathematical function which connects two variables—here, viscosity and concentration. When we say, therefore, that the shapes of the viscosity-concentration curves are different for polyelectrolytes and neutral polymers, we are in effect saying that viscosity depends on concentration in two quite different ways in the two cases. This is best illustrated if we plot the ratio of viscosity increment over concentration along the vertical axis against concentration. For neutral polymers, the data lie on a straight line, which climbs with increasing concentration. For our polyelectrolytes, the data give a curve which climbs very sharply with decreasing concentration.

Heidelberger observed in 1932 exactly this sort of viscosity curve for the sodium salt of the polysaccharide isolated from *Pneumococcus III*. Chemically, the two compounds are completely different: the synthetic material is a polypyridonium salt with a positively charged chain, whereas the polysaccharide is a polycarboxylate with a negatively charged chain. It thus appears that, just as in the theory of ordinary electrolytes, the number and distribution of charges, rather than their chemical derivation, is the fundamental variable in controlling physical properties of polyelectrolytes. As a matter of fact, if we plot

both Heidelberger's data and our own on the same graph, using a function which was empirically derived from the data on the polypyridonium compound, both sets of points fall on the same straight line. This necessarily indicates an underlying similarity despite the superficial difference in the two compounds.

It becomes necessary at this point to introduce a few mathematical symbols to facilitate further discussion. Suppose we denote concentration, our independent variable, by c . Let z stand for the measured dependent variable, the ratio of specific viscosity increment to concentration. Then the function which was found to represent the data within the limit of experimental error is written

$$z = A/(1 + B\sqrt{c}) + D,$$

where A , B , and D are numerical constants which can be obtained from the data by simple arithmetic.

For various reasons we suspected that the constant A would depend primarily on the size of the polyelectrolyte, while B would be a measure of the electrostatic interaction. By working with polymers of different molecular weights, we could show that A did indeed vary in a systematic way with polymer size. But if we had been limited to working in aqueous solutions, we would have had to stop there. Fortunately, our polymers are soluble in a variety of organic solvents such as alcohol, nitromethane, and dioxane; by measuring viscosities in different solvents, we could investigate the effect of media of different dielectric constant on the viscosity. We found that B increased with decreasing dielectric constant, which is what would be expected on the basis of Coulomb's law if B were a measure of the intensity of electrostatic interaction. Consequently, it becomes possible to predict from measurements in one solvent the behavior of a polyelectrolyte in a different medium.

We are thus led to the assumption that the high viscosity of polyelectrolytic solutions and its concentration dependence are due to the presence of the high charge density at the polyions. We may now test this hypothesis by an experiment which it suggests. At a given concentration we imagine the polycations to be surrounded by a space charge of negative ions, and, furthermore, we assume that some negative ions are held within the polymer coil by electrostatic attraction. The aggregate acts like a droplet of concentration solution with a net positive charge. The solvent between these clusters contains free-swimming anions. Suppose we add a simple one-one electrolyte like potassium bromide, which will put singly charged positive potassium ions and an excess of negatively charged bromide ions in the solution. By a simple

mass-action effect, under the influence of Coulomb attraction, we would expect the polycations to attract more negative ions (which would be repelled from the negative ionic atmosphere) and thus reduce their own net charge. If this happens, however, the long-range electrostatic effect on viscosity would decrease and, in the presence of a large enough excess of added electrolyte, should vanish. This is just what one observes experimentally. Even as dilute a solution as 0.001 N potassium bromide as solvent eliminates the sharp rise in the z - c curves near zero concentration and at somewhat higher concentrations produces linear z - c plots which closely resemble those of uncharged neutral polymers.

A further test of this model can be made if we add other kinds of simple electrolytes—for example, magnesium bromide also gives bromide ions and a doubly charged positive ion. Since the polycation would strongly repel ions of like charge, we expect—and find—that at the same bromide ion strength, magnesium and potassium bromides have identical effects on the behavior of the polysalt. On the other hand, if we add potassium sulfate, where the negative ion now has the double charge, we expect—and find—a different result as compared with potassium bromide. Similar effects have been found on the addition of neutral salts to naturally-occurring polyelectrolytes.

ELECTRICAL PROPERTIES

Conductance is a characteristic property of all electrolytes, and a study of its dependence on the pertinent variables results in a better understanding of molecular behavior and structure. Past research has established certain general principles which may be applied to any conducting system. For a given charge, a small ion moves faster, i.e. has a higher conductance, than a larger one. The higher the charge on an ion of given size, the more current it carries and hence the higher the conductance. At a given concentration, a given electrolyte has a lower conductance in a solvent of lower dielectric constant, because increased association of oppositely charged ions under the influence of electrostatic attraction decreases the relative number of ions free to carry current in the latter case. With dilution, conductance increases, due to decreasing intensity of long- and short-range ionic interaction. The conductance of the polyelectrolyte was therefore studied in various solvents in order to see what might be learned by applying these principles to the observed experimental facts.

The very first measurements of conductance showed that the polyelectrolytes were strikingly different from ordinary electrolytes. One conventionally plots the equivalent conductance against square root of concentration

tration; on this scale, where familiar electrolytes approximate linearity, the polyelectrolytes give curves which are convex to the concentration axis. This may be interpreted as due to a change in the relative number of conducting particles, to a change of mobility with concentration, or to a simultaneous change of both variables. Our results show that the latter description best fits the facts. At a given concentration a certain fraction of bromide ions are located in the solvent between polycations and are free to migrate under the influence of external electrical fields. The large polymeric ions have a certain average number of anions associated with them, but still have a net positive charge and hence also contribute to the current. Now suppose we decrease the total concentration by adding more solvent: since more space is available, some of the bromide ions previously bound to or in the polyions will move away from them as a consequence of normal Brownian motion. Two consequences appear, both of which increase conductance: the newly released anions increase the negative current, whereas the contribution of the positive ions is now greater because of their increased net charge. The latter effect will, to some extent, be compensated by a dilation of the polyion under the influence of its increased internal field.

The most direct experimental proof of the existence of ionic association in the case of the polyelectrolytes is obtained if we compare the conductance in different solvents. In a series of nitromethane-dioxane mixtures, for example, the conductance at a fixed concentration steadily decreases as the dioxane content of the solvent increases. Since dioxane has a dielectric constant of only 2.2 while that of nitromethane is nearly 40, this result is what would be expected on the basis of our model. Finally, by studying the conductance of salts of copolymers of styrene and vinylpyridine, it was possible to estimate the fraction of current carried by the two species of ions present, the small bromide ions and the large polyions. Again, the variation with structure was in agreement with predictions based on the model.

One other electrical property requires mention. Cole has shown that a variety of naturally-occurring membranes have a striking similarity in their behavior in alternating electrical fields. A plot of the power absorbed per cycle in the membrane against its dielectric constant gave a circular arc, regardless of the origin of the membrane. Copolymer salts of the type mentioned in the last paragraph are insoluble in water when the styrene content is high. Membranes were made from them, and their a-c properties were measured. The impedance locus turned out to be a circular arc also. This observation suggests that

some of the properties of biological membranes are due to the presence of ions which are immobilized in the structure of the membrane, similar to the pyridonium ions in the synthetic membranes.

OSMOTIC PRESSURE

The last property of polyelectrolytes which we shall discuss is osmotic pressure. For over a century the osmometer has been a useful tool in research, both on natural and synthetic compounds, because, in effect, it permits us to count the number of molecules which are contained in a given weight of sample. Van't Hoff's theoretical treatment of the problem was largely based on the data obtained by the botanist, Pfeffer. Very briefly stated, measurement of osmotic pressure permits determination of the molecular weight of molecules in solution and—still more important—gives information bearing on molecular interaction. Solutions of macromolecules gave osmotic pressures which were quite puzzling, until Flory and Huggins formulated a theory which showed that the deviations from behavior predicted on the basis of classical theory were due to entropy terms arising from the many configurations which, because of its flexibility, a chain molecule could assume in solution. Similarly, early work on osmotic pressures of protein solutions gave results which could not be correctly interpreted until the significance of the isoelectric point was emphasized by Loeb and until the effects of Donnan equilibria were considered. Except at the isoelectric point, the osmotic pressure of a protein solution is higher than corresponds to its molecular weight, due to the presence of accompanying counter ions.

Measurements of the osmotic pressure of synthetic polyelectrolytes have given similar results. In alcohol the osmotic pressure is over an order of magnitude greater at a given concentration than that of a neutral polymer of the same molecular weight. On the other hand, the pressure is, by far, less than would correspond to each bromide ion and each polycation contributing to the total pressure; we therefore find confirmation of our previous conclusion that polyelectrolytes are highly associated in solution.

With the pyridonium salts there is, of course, no analogue of the isoelectric point, because they are strong electrolytes and not ampholytes. The situation at the isoelectric point may, however, be simulated by the addition of an excess of simple electrolyte to the strong polyelectrolyte. When, for example, lithium bromide is added to alcoholic solutions of the pyridonium salts, the osmotic pressure is very much reduced and is not greatly different from that which a neutral polymer of the same molecular weight would give. This result, of course, parallels our ex-

periment with excess added electrolyte in the case of viscosity and leads to the same conclusions concerning association.

CONCLUSION

The purpose of this presentation has been to summarize some recent work on the physical chemistry of synthetic polyelectrolytes. In three fields—hydrodynamics, electrodynamics, and thermodynamics—we have seen that the properties of these compounds

could be described, at least qualitatively, in terms of the chain model of neutral macromolecules combined with the effects of electrostatic forces. Similarities between the behavior of proteins and polysaccharides and that of the synthetic polyelectrolytes suggest that a better understanding of the biological materials may be attained through a study of the synthetics, thanks to the controllable variability which the latter offer to the experimenter.

University of California African Expedition— Southern Section

Charles L. Camp

THE UNIVERSITY OF CALIFORNIA at Berkeley, through the Museum of Paleontology, has, during the past 15 months, sponsored a program of scientific work in southern Africa. The primary purpose has been to search for further fossil evidence of the anatomical form, habits, environment, and geological age of the remarkable australopithecine man-apes first described by Prof. Raymond Dart and elaborated by Dr. Robert Broom.

Another important objective was a coordinated series of anthropological studies on the primitive tribes of northern South-West Africa, where conditions have been favorable for the preservation of ancient customs and tribal life. Attention was directed to ethnology, linguistics, physical and cultural anthropology, psychology, ethnobotany, ethnozoology, and musicology among the Ovambo. Some work was also done among the Kung Bushmen and the few surviving Hottentots who retain traces of their original culture.

A program having to do with recent and fossil plants has been carried out successfully. Extensive collecting of recent amphibians, reptiles, mammals, and insects, including protozoan parasites of termites and studies in ethnoentomology, are being conducted by two members still in the field.

Work began in August 1947 with a survey of Cretaceous localities near Port Elizabeth. Early in September the two paleontologists, Frank Peabody and the writer, accompanied a geological excursion arranged by Dean George B. Barbour, of the University of Cincinnati. Quaternary cave and travertine sites were visited from the Makapaans valley and Thaba Zimbi, 200 miles north of Pretoria, south to Taungs, 100 miles north of Kimberley. Members of the party included Profs. Alexander du Toit, Raymond Dart,

C. J. VanderHorst, C. van Riet Lowe, and Dr. S. H. Haughton, the head of the Geological Survey.

Under their counsel it was decided to commence operations at the works of the Northern Lime Company, near Taungs, and as close as possible to the old type-site of *Australopithecus*. During the next 6 months some 30 sites were investigated in the vicinity, along the eastern edge of the Kaap Plateau from Boetsap to the quarries north of Norlim.

The earliest breccias—gray, water-washed, gravel conglomerates at the base of the Norlim lime biseuit—contain antelope and horse remains and no crushed baboon skulls such as are found in the supervening pink sandstone breccias in the *Australopithecus* zone. Above the pink breccias the travertine spring deposits are honeycombed with later, filled caves and vertical pipes containing dark brown earths and secondary lime. Many of these contain late Pleistocene artifacts and ash deposits. Still younger caves, along the outer margins of the lime bodies, remain as open cavities in which may be found brown and yellow earth, dust, ash, and bat and hyrax guano. Artifacts of pre-Bushman and Bushman types occur in these more recent deposits.

Middle Stone Age artifacts sealed in place in solidified cave floors occur with human teeth and mammal bones, south of Norlim, and the same type of artifacts were found in yellow sandy travertine at Mooiplaats, 60 miles north of Zeerust.

It is therefore believed that a number of sequential stages of Quaternary history will become recognizable when the faunas and artifacts are studied. None of the man-ape sites contains evidence of fire or artifacts. They must antedate the abundant caves in which artifacts occur.

After a month in the Mesozoic of South-West Africa and a tour of 6 weeks in the reptile beds of the Karroo, work was begun at Gladysvale, where samples were taken from the immense bone deposits in a stratified sequence of cave fills.

During the period April-July 1948, excavations were conducted at Bolt Farm, near Sterkfontein caves, and at adjoining farms and lime pits. Material was secured from 26 pits which apparently vary in age as they do in fossil content. The pink breccias in this area contain rare remains of man-apes as well as a host of mammals. The abundant rodent and insectivore remains (owl breccias) may serve to indicate climatic conditions. An elephant tooth should aid in dating. Australopithecine femora associated with baboon skulls were found in the pink breccias in two pits. The baboons, ranging from small, short-snouted species to some with jaws larger than those of a man, should be valuable as horizon markers.

A small sabre-cat, represented by three skulls and associated skeletal parts, seems to have been responsible for the litter in one cave; another may have been a jackal lair; and still others contained hyena, baboon, small monkey, pig, and a large series of antelope, carnivore, and horse bones and teeth.

Reptilian and amphibian material from the Karroo was secured mainly in the upper zones of the Beaufort and the Stormberg. Skeletons of late mammal-like forms, *Cynognathus*, *Trirachodon*, and others, were obtained near Rouxville. An average of four good specimens were taken each day during the 6-week period, indicating the great wealth of fossils constantly coming to light as these soft beds are eroded away. The Bernard Price Foundation has given the University a fine lot of additional Karroo material in exchange for the use of a truck.

There is no other known area where such an abundant and varied reptilian fauna occurs. The earliest known ancestry of the mammals, the crocodiles, the lizards, and the turtles is represented in these beds, which also provide a good view of the history of many extinct reptilian families.

The vertebrate history represented in South Africa fills two main gaps in the North American record—the late Permian and Middle Triassic, and the early history of man.

It was with these thoughts in mind that the paleontological program was organized, and it was carried out with generous assistance from the Geological Society of America, the American Philosophical Society, and the National Academy of Sciences.

The geological work was done by Profs. Barbour and Peabody and the writer, and a report on the Taung area is now being completed. New evidence

concerning distribution of Mesozoic beds and faunas in South-West Africa is being incorporated into the latest edition of du Toit's *Geology of South Africa*.

Through the courtesy of Prof. C. Van Riet Lowe, head of the Archaeological Survey and the Department of Archaeology, Witwatersrand University, a member of his staff, Dr. B. M. Malan, accompanied and guided two members of the expedition on a three-week exploration of Wonderwerk Cave, near Kuruman. A sequence of levels in this large cave produced evidence of cultures as far back as early Stone Age, accompanied by faunas.

Artifacts collected by the Expedition are now being studied by Dr. Malan, and duplicate series will be sent to us after the papers are written.

The anthropological survey in all its branches was conducted by the ethnologist, Dr. Edwin M. Loeb. On the first long trek into Ovamboland his party consisted of Dr. and Mrs. Loeb, the artist and photographer; Boris Ifund, the psychologist; the two musicologists, Mrs. Laura Boulton and Charles M. Camp; and Mr. Eric W. Williams, the technician from Prof. Dart's laboratory of physical anthropology at Witwatersrand University in Johannesburg.

A second expedition to South-West Africa by the Loeb party was made in the spring of 1948 and was accompanied by Dr. L. H. Wells, the physical anthropologist from Prof. Dart's staff, and by Dr. Carl Koch, the entomologist.

Ethnological work was chiefly concentrated on the Kuanyama Ovambo. Preliminary data have been published by Dr. Loeb in *African studies* (Witwatersrand University, March and September 1948). He states:

The Kuanyama are a dual culture resulting from the admixture of cattle-raising Hamites from the north with the agricultural (hoe culture) negroes of Africa. These two layers were probably superimposed on a primitive hunting and fishing culture similar to the Bushman. A study of the isolated primitive Kuanyama culture will give a new appraisal of the resulting contacts between hoe-agriculture and early cattle-raising peoples, not only as elsewhere in Africa, but in the Mediterranean World, as well. For example, the agricultural peoples in the areas tend to be matrilineal, whereas the cattle-raising peoples are uniformly a patrilineal social organization. These agricultural peoples have developed the plastic arts, but the politically minded cattle-raisers have neglected the plastic arts and have tended to dominate the more passive agricultural peoples, suppressing the women and children in their social relations. The correlation of ethnological traits with the psychological studies of the individual personality will show the overt and introvert adjustments of age and sex groups to the complexities of a dual agriculture and cattle-raising organization.

Data were secured on a wide range of ethnological, linguistic, psychological, and physical problems. Measurement indices seem to indicate the presence of Hamitic trends in the Kuanyama and of Mongoloid in the Bushman.

Plastic facial and bodily masks and casts, physical measurements, photographs, cinematographs, Kodachrome and Ektachrome slides and transparencies, and drawings and paintings were obtained. Extensive grammatical notes, word lists, translations of texts, and phonetic data were made. Cultural objects collected include articles of dress, utensils, and weapons.

The botanical work, independently carried on by Mr. Robert J. Rodin, of the University Herbarium, resulted in the collection and identification of 35,000 pressed plants, 500 live plants, mostly succulents, as well as seeds, bulbs, seaweeds, fossil leaves, and wood from the petrified forest discovered in the Kaokoveld by the Expedition. Forage grasses from the Kalahari were obtained for the agricultural experiment stations and may prove to be serviceable on the arid ranges of the southwestern United States. Ethnic and medicinal plant uses were recorded in the native territories, and seasonal plant food charts were obtained as a contribution to ethnobotany. Cooperation was secured from the members of Dr. Loeb's party, with whom Mr. Rodin stayed for a time, and from the botanists, botanical gardens, and herbaria of South Africa and Kew Gardens in England. Dr. Koch and Mrs. Loeb also added to the plant collections. Interesting studies and color photographs were made of the peculiar xerophytic floras of the Namib Desert, especially of the curious relict gymnosperm, *Welwitschia* (*Tumboa*).

Mr. Rodin collected in the mountains of southern Rhodesia as well as throughout South and South-West Africa.

Mr. Thomas J. Larson, the mammalogist, obtained 1,000 study skins of recent mammals as well as skulls and skeletons for comparison with fossils from the Quaternary caves. Among the mammals are a good series of recent baboon skulls, lion skulls in several growth stages, a skeleton of the rare insectivorous hyaenid, *Proteles*, series of golden moles, elephant shrews, embryological and complete material in alcohol for anatomical study. Special attention was paid to rodents, antelopes, and other forms commonly found in the fossil deposits. Several hundred specimens of amphibians and reptiles were collected by Mr. Larson and other members of the Expedition.

The entomologist, Mr. Carl Koch, arrived from Austria in April 1948 and joined the second Loeb party into Ovamboland. In that short time he collected some 30,000 insects, especially tenebrionid beetles, and also protozoan parasites of termites from regions where such material has not previously been collected. He and Mrs. Loeb have listed the uses of over 30 animals, and he has also determined some interesting uses of insects in native food, magic, and poisons. His continued work this fall will carry him again across the Kalahari and into Ovamboland, Portuguese Angola, and the Kaokoveld.

Native songs and instrumental music permeate the life of the tribes, as long as tribal life is allowed to continue. With the decay of the tribal communities and the incursion of white influences, this stimulating and unique phase of the South African scene will disappear. Native music has developed into rhythmic forms which are more complex and interesting than those in other parts of the world. The accuracy and effectiveness of these patterns of interlocking rhythms carry African music into a sphere of its own.

The Expedition devoted attention to recording and translating songs, chants, dances, and instrumental and orchestral material. A panel van was fitted up with a large Presto recorder run by batteries, and records were made among many native groups throughout South Africa, South-West Africa, northern and southern Rhodesia and central Angola.

Mrs. Laura Boulton was with the party during the first half of the year; during the second part Mr. Hugh Tracey and his newly established African Musical Research Institute gave exceptional aid to Mr. Charles M. Camp, of our group. The nearly 1,000 recordings which were secured will be available to students at Berkeley and Los Angeles. Mr. Tracey has also agreed to send further recordings and translations made by his laboratory to the University and to provide means for students from the University to study in the field. In return for this, Mr. Tracey has been supplied with copies of records made by Mr. Camp this spring, as well as the use of transportation facilities.

The Expedition is deeply grateful to the General Motors Corporation, the Shell Oil Company, the Presto Company of New York, the Farrell Steamship Lines, Ingersoll-Rand Ltd., of Johannesburg, The Union Defense forces of South Africa, the University of Witwatersrand, and many other individuals, officials, and institutions for generous aid.

Triennial Meeting of the International Astronomical Union

Harlow Shapley

Harvard College Observatory

IN THESE TIMES, when the difficulties of communication and cooperation between eastern European countries and those of western Europe and America are much emphasized, it is worth noting that astronomers from Finland, Russia, Poland, Czechoslovakia, Hungary, Austria, and eastern Germany joined western astronomers in attending the triennial meeting of the International Astronomical Union in Zurich, Switzerland, in August of this year and took an active, but by no means dominating, part in the week-long activities. The Russian astrophysicist, V. A. Ambartsumian, was elected to one of the vice-presidencies of the Union. Th. Banachiewicz, of Warsaw, Poland, is the new president of the Commission on the Motion and Figure of the Moon; A. Mikhalov, director of the Pulkowa Observatory which is now being reconstructed after its complete destruction during the siege of Leningrad, has been made president of the Commission on Astronomical Telegram Service; and B. W. Kukarkin, of Moscow, is the new vice-president of the important Commission on Variable Stars.

The Union assigned to a group at the Moscow Observatory, working under the supervision of an international committee, one of the most important services provided for general use by observers, namely, the cataloguing, ephemeris-computing, and publication of variable stars.

The Academy of Sciences of the USSR, through its astronomical section, invited the Union to hold its next meeting in Leningrad in 1951. An invitation for 1951 was also received from the Mount Wilson and Palomar Observatories.

The Zurich meeting was the seventh since the organization of the Union at the end of World War I. At earlier meetings the Union had worked on problems of cooperation in special fields, such as the variation of latitude, the business of time-keeping, the systematic following of sunspots, and the mapping of the stars on a uniform basis. The present activities of the Union include these among many others. They are handled by nearly 40 international commissions. Because of the large number of active observatories in the United States, the American astronomers are numerous in the personnel of the commissions and were elected to many of the presidencies. The American presidents and their commissions are as follows:

Yerkes Observatory—S. Chandrasekhar (constitution of the stars), Otto Struve (interstellar matter); Mount Wilson Observatory—Walter Baade (star clusters), E. P. Hubble (extragalactic nebulae); U.S. Naval Observatory—G. M. Clemence (celestial mechanics), Paul Sollenberger (variation of latitude), C. B. Watts (meridian astronomy); Yale Observatory—Dirk Brouwer (minor planets, comets, satellites); Brown University—Otto Neugebauer (history of astronomy); Bureau of Standards—W. F. Meggers (standard wave lengths); Harvard Observatory—Zdenek Kopal (close binaries), D. H. Menzel (solar eclipses), Harlow Shapley (international observatories), F. L. Whipple (meteors).

The new president of the International Astronomical Union is Bertil Lindblad, director of the Stockholm Observatory, and the general secretary is Bengt Strömgren, director of the Royal Observatory of Denmark.

Among the activities of particular interest at the Zurich meeting were the following:

(1) A new commission on microwave astronomy was set up. Much interest has developed during and since the war in the use for astronomical exploration of the radio waves in the interval from 1 cm up to 15 m in length. The astronomical applications include the recording of meteors in daylight and in any kind of weather through the use of radio echoes; the bouncing of radio waves off the moon; the newly discovered solar "noise"; and the cosmic static which appears to be registering both the Milky Way (especially the nucleus) and some strange "hot spots" in space. The Australian, English, and Canadian astronomers and physicists have taken the lead in this field, and an Australian, Richard Woolley, is the president of the new microwave commission.

(2) The report by the director of the International Bureau on the Variation of Latitude, Luigi Carnera, of Italy, contained an analysis of the wanderings of the poles of the earth during the past two decades. The results were derived from observations provided by an international group of stations located on the same latitude circle in Russia, Japan, Italy, Maryland, and California. Apparently only the Russian and Japanese stations were uninterrupted during the war.

(3) Bernard Lyot, the distinguished French astrophysicist who invented the coronagraph, brought to

the meeting and displayed effectively a new device for the detailed study of the surface of the sun. It is a birefringent light-filter, similar to those in use at Harvard's station at Climax, Colorado, but with a narrower transmission band (0.8 Å) which permits the high resolution of solar features and the study of finer details.

(4) Grants-in-aid were made for a dozen international projects in Poland, Denmark, Italy, France, England, and the United States. (The Union's expenses are borne by levies on the participating member-nations.) The three grants to Americans were made to assist in (1) publication of a table of wave

lengths prepared at the National Bureau of Standards, (2) revision and publication of the Yale Catalogue of Stellar Parallaxes, and (3) operation of a bureau in the Cincinnati Observatory for special studies on the minor planets.

The most serious difficulty in holding such international meetings at the present time is associated with monetary exchanges. Swiss francs could not be obtained by many members who otherwise would have attended. Thanks to a grant from UNESCO and to private gifts, mostly from American astronomers, a number of German and Austrian astronomers were able to attend. More than 50 Americans were present

TECHNICAL PAPERS

Variation Induced by Uranium Nitrate in Corn Smut and the Cultivated Mushroom

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The addition of uranium nitrate, $\text{UO}_2(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$, to potato-dextrose agar at the rate of 0.5–1.0 gm/liter has stimulated mutation in the cultivated mushroom, *Agaricus campestris*, and both mutation and an unusual type of dissociation in the ordinary corn smut fungus, *Ustilago zeae*.

The experiments on *Ustilago zeae* were made with two monosporidial haploid lines, designated as 10A4 and 17D4, and with several monosporidial diploid lines resulting from crosses between the two and designated as 410qq and 410n. Line 10A4 is very stable under a normal range of conditions, and 17D4 is moderately mutable. As these lines are haploid and unisexual, neither will cause infection when inoculated singly into corn plants. When corn is inoculated with a combination of the two, however, infection results, and galls containing morphologically normal chlamydospores are formed. On germination, however, a high percentage of the promycelia produced by the chlamydospores undergo partial or complete autolysis at various stages of development because 10A4 carries a dominant factor for this character, which is associated with a tendency for sporidia to be diploid instead of haploid.

Monosporidial diploid lines, like haploid lines, can be propagated on artificial media but can cause normal infection when inoculated singly into corn plants, with consequent production of normal galls and chlamydospores. The diplophase may persist for several successive chlamydospore generations and usually has persisted indefinitely when diploid lines are grown on artificial media. Numerous attempts to induce reduction division

or dissociation into haploid parental types on artificial media had failed until uranium nitrate was added to the medium.

Diploid line 410qq, intermediate in cultural characters between its parents, 10A4 and 17D4, but resembling the unstable 17D4 somewhat more closely, produced an unusually large number of mutants when grown on potato-dextrose agar containing 1 gm/liter of uranium nitrate. This was true of 17D4 also. Some of the mutants of 410qq resembled 17D4 and some of its mutants closely in cultural characters; they failed to cause infection when inoculated singly into corn plants but caused normal infection when combined with 10A4. It appears therefore, that uranium nitrate induced reduction division or some other type of nuclear change that resulted in the dissociation of the 17D4 factors for cultural characters, sex, and pathogenicity from their combination with those of 10A4. No lines were obtained that resembled the 10A4 parent closely. The results are definite, but precise explanation for them is lacking.

Extensive experiments were then made on the effects of uranium nitrate on frequency of mutation in 10A4, 17D4, and diploid lines 410n, which resembles 10A4 in cultural characters, and 410qq, which resembles 17D4. In the relatively unstable lines 17D4 and 410qq, 3–8 times as many mutants appeared on the medium containing uranium nitrate as on that without it, the ratio varying with the line of smut, the concentration of uranium nitrate, and the temperature at which the cultures were grown. With the relatively stable lines 10A4 and 410n, the effect of uranium nitrate was even more pronounced, although their mutants have not yet been studied thoroughly. There is evidence also that the number of mutants produced in liquid media containing uranium nitrate may be even greater than on agar.

Primary and secondary mutants of 17D4 have been studied extensively, primary mutants being those derived directly from 17D4 and secondary ones, those

derived from the primary ones. The most noteworthy facts about the 180 mutants studied are that all 10 of the primary ones grew better than 17D4 on uranium nitrate medium, that none of the 180 have lost any essential growth factors, and that some of them exceed 17D4 in certain characters such as color and rate of growth.

Studies with monosporous isolates of the cream variety of the common cultivated mushroom, *Agaricus campestris*, have yielded similar results. Uranium nitrate and other uranium salts have induced mutants whose growth on artificial media is from 5 to 7 times that of the original lines, as determined by dry weight of mycelial mats. Moreover, spawn of some mutant lines has produced mushrooms earlier than that of the checks, and the color was white instead of brownish.

The agar containing uranium nitrate is mildly radioactive, as determined by Dr. Alexander Hollaender, Oak Ridge National Laboratory.

It is suggested that the addition of uranium nitrate, or other similar salts, to nutrient media may be a simple and useful means for inducing desirable mutations in at least some microorganisms.

Changes in the Blood Following Exposure to Gaseous Ammonia

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The use of ammonia as a solvent and as a reagent has opened a new field, and many chemical industries are using anhydrous liquid ammonia in large quantities. Because of leaks in reactors and the transfer of ammonia, the concentration of gaseous ammonia in the air can be of such amounts as to have definite physiological effects upon long exposure. Such has been the case in these laboratories, where investigations utilizing anhydrous liquid ammonia have been carried out over a period of 15 years. Students have noticed such physiological effects as initial exhilaration and increased frequency of respiration with subsequent exhaustion lasting several hours after exposure. There seems to be no lasting detrimental effect, however.

It was thought that it would be interesting and profitable to collect some data pertaining to the accumulation of ammonia by the blood through breathing as a by-product of these investigations.

It has been known for some time that inhalation of ammonia lowered the blood pressure, but no quantitative data pertaining to this are available. A study has been made to show how the blood pressure varies with time when breathing a constant concentration of the gas. In this paper is also presented the change in the NPN (non-protein nitrogen) and the carbon dioxide-combining power of the blood plasma.

In these studies the air in the room was kept at a constant concentration of ammonia, varying less than 30

ppm over 4 hrs. The ammonia concentration was determined twice during this time, at the beginning and at the end. Samples of air were drawn into an evacuated flask, the volume computed to 760 mm, 25 ml of water added, and the solution titrated with 0.1 normal acid. The concentrations of ammonia in the air varied between 530 and 560 ppm.

TABLE 1

1. VARIATION OF NPN AND AMMONIA WITH TIME OF BREATHING GASEOUS AMMONIA

Time of breathing (hrs)	NPN (mg %)	NH ₃ (mg %)	Urea (mg %)	Creatinine (mg %)
Normal	27.0	00.0	15.0	1.5
1	37.0	12.1	15.0	1.6
2	45.0	21.9	15.0	1.6
3	50.0	27.9	15.0	1.6
4	57.0	36.4	15.0	1.6

2. CHANGE IN THE NPN AND AMMONIA WITH TIME AFTER CESSATION OF BREATHING GASEOUS AMMONIA FOR 3 HRS

Normal	NPN	NH ₃	Urea	Creatinine
Normal	27.0	00.0	13.0	1.5
1	47.5	24.9	13.0	1.5
2	40.5	16.4	13.0	1.5
3	32.5	6.6	13.0	1.5

The subject, the senior author, remained in contact continuously with the air-gas mixture. Samples of his blood were drawn at regular intervals from a vein in the

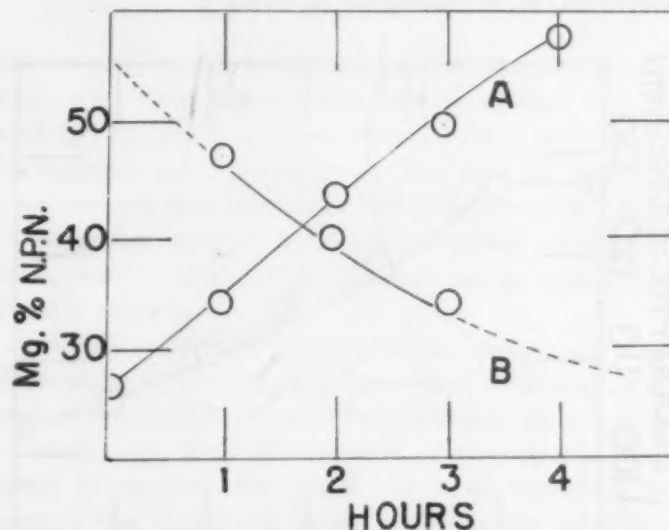


FIG. 1. Rate of change in the blood NPN upon exposure to ammonia: (A) absorption of ammonia by the blood, (B) elimination of ammonia by the blood.

arm and were analyzed for NPN, urea, and creatinine according to the method of Folin and Wu (1). The carbon dioxide-combining power of the blood was determined by the method suggested by Van Slyke and Cullen (2). pH determinations of the whole blood were made before and after breathing ammonia for 3 hrs, by means of a quinhydrone electrode. No significant change was noticed (7.35; 7.29).

As shown in Table 1 and Fig. 1, the NPN and ammonia vary regularly with time, while the urea and creatinine content of the blood show no variation what-

soever. Upon cessation of breathing ammonia, the NPN drops regularly to the normal value, but at a slower rate than it was absorbed. It was thought at first that there would be an increase in the urea content of the blood through conversion of ammonium carbonate into urea, but such does not seem to be the case. An examination of the urine for excess urea and ammonium salts over the normal gave no further clue. The amount of increase in the urea or ammonium salt formed by the ammonia inhaled would be insignificant compared to the normal amount excreted in a 24-hr sample.

TABLE 2
CARBON DIOXIDE-COMBINING POWER OF THE
BLOOD PLASMA

Time (min)	Volume (% CO ₂)
Series I	
0	56
120	57
180	57
Series II	
0	52
90	48
Series III	
0	52
60	53
120	50

The carbon dioxide-combining power of the blood plasma apparently is not impaired by the accumulation of ammonia, as is illustrated in Table 2.

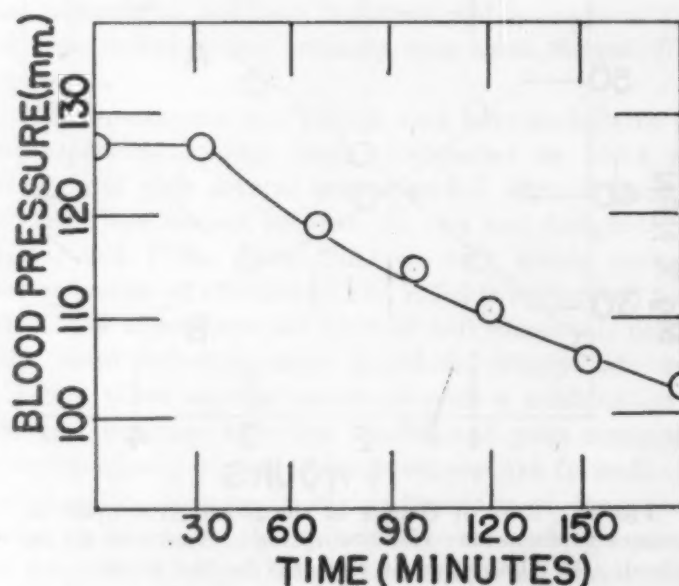


FIG. 2. Change in blood pressure with time upon exposure to gaseous ammonia.

The pulse rate, determined at regular intervals during each experiment, was found to be constant. Blood pressures taken on the subject showed a regular drop after the first 35 min of inhalation. A typical determination is shown in Fig. 2.

No attempt is made to explain the mechanism of the absorption of ammonia by the blood. The authors feel sure, however, that it is a chemical process and not a physical one. It seems to be a second-order reaction.

The data are presented in the hope that more work will be done on this problem.

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Inhibition of Mitotic Poisoning by *meso*-Inositol¹

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The studies briefly reported here stem from several observations recorded in the literature. The strong insecticidal agent, γ -hexachlorocyclohexane (Gammexane) has a cytological effect on *Allium Cepa* similar to that of colchicine. It produces the phenomenon known as c-mitosis, which is characterized by the arrest of nuclear division in the metaphase and, on longer exposure, formation of c-tumors.

TABLE 1
TUMOR FORMATION

Medium* (mM/liter)			Medium* (mM/liter)		
Mitotic poison	Inhibit- ing agent	c-Tumors†	Mitotic poison	Inhibit- ing agent	c-Tumors†
0.025 C	...	-(2)	0.035 G	...	+(4)
0.25 C	...	+(4)	0.35 G	...	+(3)
0.25 C	0.33 mI	± (2)	0.035 G	0.33 mI	± (3)
0.25 C	3.3 mI	-(6)	0.035 G	3.3 mI	-(5)
0.25 C	2.0 S	+(2)	0.35 G	3.3 mI	± (3)
0.25 C	3.3 dI	+(2)	0.035 G	3.3 dI	+(2)
....	...	-(5)	0.035 G	2.7 S	+(3)
....	0.66 mI	-(2)	0.25 S	-(2)

* C = colchicine; G = Gammexane; mI = *meso*-inositol; dI = *d*-inositol; S = D-sorbitol.

† += tumors on all roots; ± = small tumors on some of the roots; - = no tumors. The figures in parentheses indicate the number of bulbs examined.

tion of c-tumors. Other isomeric hexachlorocyclohexanes are either ineffective or only slightly active (5). The

¹ This work was supported in part by a grant from the American Cancer Society on the recommendation of the National Research Council Committee on Growth.

² Now geneticist, Division of Fruit and Vegetable Crops and Diseases, Bureau of Plant Industry, Soils, and Agricultural Engineering, USDA. The investigation was begun at the Department of Botany, Barnard College, New York, where the author was employed.

same agent interferes with nuclear division in *Paramecium caudatum* and produces distorted forms of growth (3). Regardless of the exact sterical configuration of the various hexachlorocyclohexanes, they are all analogues of the corresponding hexahydroxy compounds,

For the study of the effects on mitosis, 10 bulbs with a large number of roots were selected. From 2 to 5 roots were removed from each bulb for each of the 16 individual experiments recorded in Table 2. All roots were exposed for 4 hrs at 19° C to mixtures of the various

TABLE 2
CYTOLOGICAL EFFECTS*

	Experiment No.															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Mitotic poison	0.25 C	2.5 C	0.25 C	0.25 C	2.5 C	0.25 C	0.25 C	0.035 G	0.35 G	0.035 G	0.35 G	0.35 G	—	—	—	—
Media (mM/-liter)																
Inhibiting agent	—	—	3.3 mI	33 mI	33 mI	33 S	33 dI	—	—	3.3 mI	33 S	33 dI	33 mI	33 S	33 dI	—
Bulb No.	Per cent affected metaphases per root															
I	82	90	18	24	94	72	100	74	94	26	86	90	2	4	14	10
II	76	94	12	22	82	18†	94	84	82	20	90	94	6	2	12	8
III	80	96	6	14	72	86	96	86	92	14	84	86	10	6	10	6
IV	82	86	12	10	18	84	88	84	92	18	86	84	6	10	16	12
V	94	94	20	6	30	84	90	86	90	20	96	86	12	4	6	10
VI	80	92	16	6	18	82	92	80	94	14	94	94	10	12	4	6
VII	76	92	20	10	30	78	94	82	90	10	90	90	6	10	6	10
VIII	86	96	18	2	18	80	90	78	96	10	96	96	12	14	4	4
IX	86	90	18	10	66	86	96	82	86	18	90	94	12	4	10	8
X	84	94	16	6	16	78	90	84	96	18	94	90	4	6	6	8
Average	83	92	16	11	44	75	93	82	92	17	91	90	8	7	9	8

* See Table 1 for abbreviations used.

† Other roots of the same bulb showed c-mitosis.

the inositols, which are of great biological interest. The remarkable specificity of *meso*-inositol as an essential agent in the growth of microorganisms has been discussed repeatedly (6, 9). The important specific influence of the relative sterical positions of the substituent hydroxyls in the various inositols was demonstrated recently with respect to the enzymatic oxidation of these stereoisomers (4).

It has now been found that *meso*-inositol is able to inhibit the metaphase arrest and tumor formation induced in *Allium Cepa* by colchicine or by Gammexane. This effect appears to be specific; *d*-inositol and *D*-sorbitol are inactive.

Onion bulbs were placed with their bases resting on the rims of glass jars filled with tap water. Roots approximately 2.5 cm long were formed in 3 days. For the observation of tumor formation, the entire bulbs with roots still attached were transferred to jars containing the various mixtures of mitotic poisons and substances being tested as inhibiting agents and kept at 18°–25° C for 48–72 hrs (Table 1). Colchicine, U.S.P. (Inland Alkaloid Co., Tipton, Indiana, or Merck & Co.), and the substances tested as inhibiting agents were employed as aqueous solutions. γ -Hexachlorocyclohexane (obtained through the courtesy of Dr. J. P. Baxter, Imperial Chemical Industries, Ltd., Widnes, England) was made up as a 0.033 M solution in ethanol and diluted with tap water to the desired concentrations.

mitotic poisons and inhibiting agents in small vials. The roots were then killed with absolute ethanol and acetic acid (3:1), and propiono-carminic smears were prepared for microscopic examination. The first 50 metaphases were counted and classified. All metaphases in which the chromosomes were split, but still attached at the centromere, were considered as affected, i.e. as c-mitotic (see Figs. 1 and 2).

Whereas γ -hexachlorocyclohexane, because of chemical similarities, could have been suspected of acting as a biological antagonist of *meso*-inositol, this does not apply to colchicine. Even in the case of Gammexane the evidence is not entirely clear. In some instances *meso*-inositol has been reported to overcome the inhibition of microbial growth by this agent (1, 2). In other biological systems, however, no such effects were observed (7, 8). It is possible that these discrepancies would disappear if different amounts and proportions were tested. That the ratio of mitotic poison to inhibiting agent is not the only factor is shown by a comparison of Experiments 3 and 5 in Table 2.

It is too early to speculate on the mechanism of the remarkable cytological effect of *meso*-inositol reported here. Additional poisons of mitosis, including those affecting other phases of nuclear division, will have to be examined before the conclusion that *meso*-inositol is involved specifically in the metaphase, or perhaps in the formation of the spindle, is justified. It is not unlikely

that the cellular component with which colchicine and Gammexane interfere is not *meso*-inositol itself, but a



FIG. 1. Metaphase in *Allium Cepa* treated with 0.00035 M Gammexane and 0.033 M *d*-inositol solution, showing failure of the *d*-inositol to inhibit c-mitosis. (Magnification, approximately 1,000 \times .)

substance to which it gives rise and the formation of which is prevented by the mitotic poisons in question.

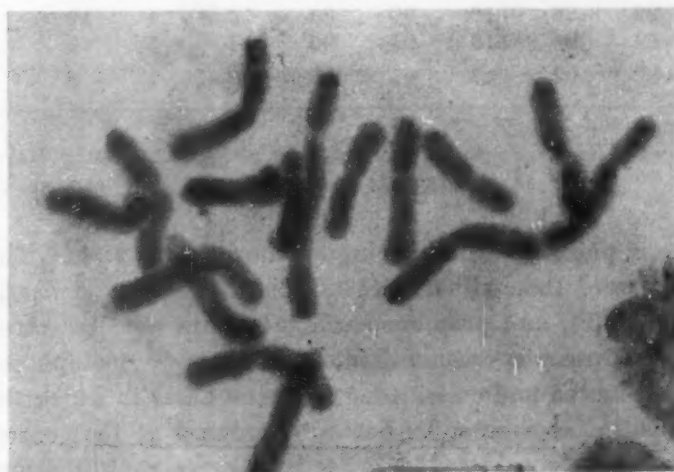


FIG. 2. *Allium Cepa* treated with 0.00035 M Gammexane and 0.0033 M *meso*-inositol solution, showing inhibition of c-mitosis. (Magnification, approximately 1,000 \times .)

Experiments on these and other aspects will form the subject of a detailed communication which will appear at a later date.

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Biosynthesis of Radioactive Drugs Using Carbon 14¹

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The therapeutic dose of many important drugs is so small that neither the compound itself nor its possible breakdown products can be detected in the body by ordinary chemical or biological methods. Incorporation of radioactive isotopes into such drugs makes possible studies of their distribution and fate in the animal organism because of the great sensitivity of the isotope tracer technique. Obtaining the organic compound containing the isotope constitutes the major practical difficulty in the application of this technique to biological problems. At the present time many of the needed compounds can be prepared only by biological synthesis.

This report deals with our experiences in obtaining radioactive digitoxin and nicotine from the medicinal plants *Digitalis purpurea* and *Nicotiana rustica*.

Plants were grown from seed and transplanted into suitable containers containing soil, sand, or crushed mica. Growth was supported by an inorganic nutrient solution containing calcium nitrate (0.1%), magnesium sulfate (0.06%), potassium nitrate (0.05%), potassium acid phosphate (0.04%), ammonium sulfate (0.01%), and smaller amounts of other salts needed in trace amounts (2). As soon as the young transplanted plants were sufficiently well established, they were sealed in a closed system, usually consisting of two battery jars placed with their open ends in apposition. Suitable holes were drilled in the glass jars for the introduction of nutrient solution and of radioactive carbon dioxide, for the attach-

¹ This work was aided by grants from the Life Insurance Medical Research Fund, the U. S. Public Health Service, and the Dr. Wallace C. and Clara A. Abbott Memorial Research Fund of the University of Chicago.

Because work of this kind involves many techniques unusual for the pharmacologist and because certain precautions must be taken when radioactive substances are used, we consulted numerous colleagues in our own University and elsewhere. Among the many who aided us, we should acknowledge especially the help of Dr. Austin Brues, chief of the Biological Division, Argonne National Laboratory, and Dr. Wright Langham and Lloyd Roth, Los Alamos Scientific Laboratory, who instructed us in the procedures used in the assay of radioactive carbon and in the necessary precautions. Dr. Crooks, of the U. S. Department of Agriculture, offered helpful hints concerning the culture of these plants and also furnished us with seeds. Dr. Burris, of the University of Wisconsin, kindly gave us the benefit of his experience with techniques in plant culture and in the study of plant respiration. Prof. Ezra Kraus, chairman of the Department of Botany, University of Chicago, gave us many suggestions and also placed at our disposal the facilities of the University's greenhouses, where the chief gardener, Mr. Michael Costello, was indispensable to us in the seeding, transplanting, and care of the plants in the greenhouse. We are also grateful to the Lilly Research Laboratories and to the Sandoz Chemical Company for generous supplies of the pure glycosides.

² Lederle Fellow in Pharmacology.

ment of a water manometer to determine adequacy of the sealing, and for drainage. The enclosed volume was approximately 22 liters. Three 40-watt fluorescent lights were placed 24" above the plants. Preliminary experiments showed that digitoxin and nicotine could be synthesized by the plants under these conditions.

CO₂ was generated from a solution of sodium carbonate containing 1, 10, or 100 μ c of C¹⁴ and 1 mM of carbonate/cc by placing 1 cc into a 50-cc syringe having a two-way valve and adding an excess of sulfuric acid. The CO₂ was injected into the closed system containing the plant. Gas samples were analyzed for C¹⁴ from time to time, thus giving a measure of the CO₂ uptake by the plant. After 2-6 weeks the plants were harvested, air dried, and pulverized.

Radioactive digitoxin. A 30-gm sample of the dried and powdered *Digitalis purpurea* plant was mixed with 500 cc of 50% alcohol and the mixture allowed to stand overnight. It was filtered through a sintered glass filter and the residue washed twice with 250-cc portions of 50% alcohol. The combined filtrates were evaporated to a thick paste at or below room temperature under a current of air, the volume restored to approximately 10 cc with water, 100 mg of sodium bicarbonate added, and the suspension extracted three times with 30-cc portions of chloroform. The chloroform extracts were evaporated to dryness, 10 cc of chloroform added, and the solution filtered through a 5 x 50-mm adsorption column of water-alcohol-chloroform washed 60-80 mesh Decalso. The chromatogram was developed with 30 cc of chloroform, then with 30 cc of 1% ethyl alcohol (95%) in chloroform (U.S.P. XIII), and the digitoxin fraction eluted with 3% alcohol-in-chloroform. After evaporation of the solvent, the residue was dissolved in chloroform and adsorbed and eluted as before. The residue from the 3% alcohol-in-chloroform eluate was dissolved in 0.2 cc of chloroform, 2 cc of carbon tetrachloride and 5 cc of petroleum ether added. After removal of the precipitate by centrifuging, it was dried and weighed. Seven mg were obtained.

A solution of the isolated material, when injected into the ventral lymph sac of frogs, resulted in systolic arrest of the heart with doses of 4 μ g/gm of frog. Similar results were obtained with known digitoxin. Colorimetric assays (1) of extracted and known digitoxin solutions were also in agreement. The majority of the radioactivity contained in 0.1 mg of the isolated material was recovered in the precipitate when 10 mg of known digitoxin was added as a carrier and the material recrystallized from dilute alcohol. The level of radioactivity was such that 2,000 cpm/mg were obtained from a 10-cm² surface with an end-window Geiger counter when plants exposed to 100 μ c of C¹⁴ were used. Subsequent experiments indicate that higher amounts of the isotope (approximately 400-700 μ c/plant) may be used.

Radioactive nicotine. The stems, leaves, and roots of the radioactive *Nicotiana rustica* plant were ground with 70 cc of 0.1 N sodium hydroxide in a Waring blender. The homogenate was steam distilled, and 450 cc of distil-

late were collected in 20 cc of 0.5 N hydrochloric acid. This solution was analyzed for nicotine qualitatively by the characteristic absorption curve between 220 and 290 m μ and quantitatively at the absorption peak at 260 m μ , measured with the Beckman ultraviolet spectrophotometer. The solution was then concentrated to 50 cc on a steam bath, the pH adjusted to 2.3, and 5 cc of 12% silicotungstic acid added for each milligram of nicotine in the solution. The mixture was warmed on the steam bath for 30 min and allowed to cool overnight. The precipitate was filtered, washed with 10 cc of .005 N hydrochloric acid, and dissolved with 10 cc of 0.5 N sodium hydroxide. This solution was extracted by shaking with 50 cc of ethyl ether in a 125-cc separatory funnel and the aqueous phase re-extracted with another 50-cc portion of ether in a second separatory funnel. The ether phases were successively washed with 10 cc of 0.1 N sodium hydroxide and extracted with successive 3-cc portions of 0.1 N hydrochloric acid. This purified acid extract was made up to 10 cc and again analyzed spectrophotometrically for nicotine. The radioactivity was measured by spreading an aliquot of the solution on a 10-cm² surface, drying, and counting with an end-window Geiger counter. Ten thousand six hundred cpm/mg of nicotine were obtained when 100 μ c of C¹⁴ were used for the plant.

Evidence that the material isolated from *Digitalis purpurea* is digitoxin lies in the specificity of the extraction procedure, the agreement between chemical and biological assay procedures, and experiments which show the radioactivity to persist in the digitoxin recrystallized from a 1:100 mixture of radioactive and nonradioactive digitoxin. As yet we have no direct information as to which carbon atoms are labeled or, in fact, whether the sugar or the genin moiety of the digitoxin is so tagged. However, since the only source of new carbon for the synthetic processes of the plant was the CO₂ of the atmosphere, random labeling of all carbon compounds must occur. This may be an advantage in the use of such materials in biological problems, since it permits the tracing of all carbon-containing metabolic fragments of the drug rather than only the single atom usually labeled in synthetic drugs.

Evidence for the purity of the nicotine prepared from *Nicotiana rustica* is found in its ultraviolet absorption curve, the reaction with silicotungstic acid, the ether-water solubility characteristics of the material, and by the melting point of the picrate (218°).

Biological experiments with these drugs are in progress and will be reported elsewhere. Other plants, including *Digitalis lanata*, *Papaver somniferum*, and *Atropa Belladonna*, are also being investigated.

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A Device for Controlling Humidity in Biosynthesis of Drugs¹

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In the course of experiments on the biosynthesis of labeled drugs we encountered some difficulty in growing young *Digitalis lanata* plants in a sealed atmosphere.

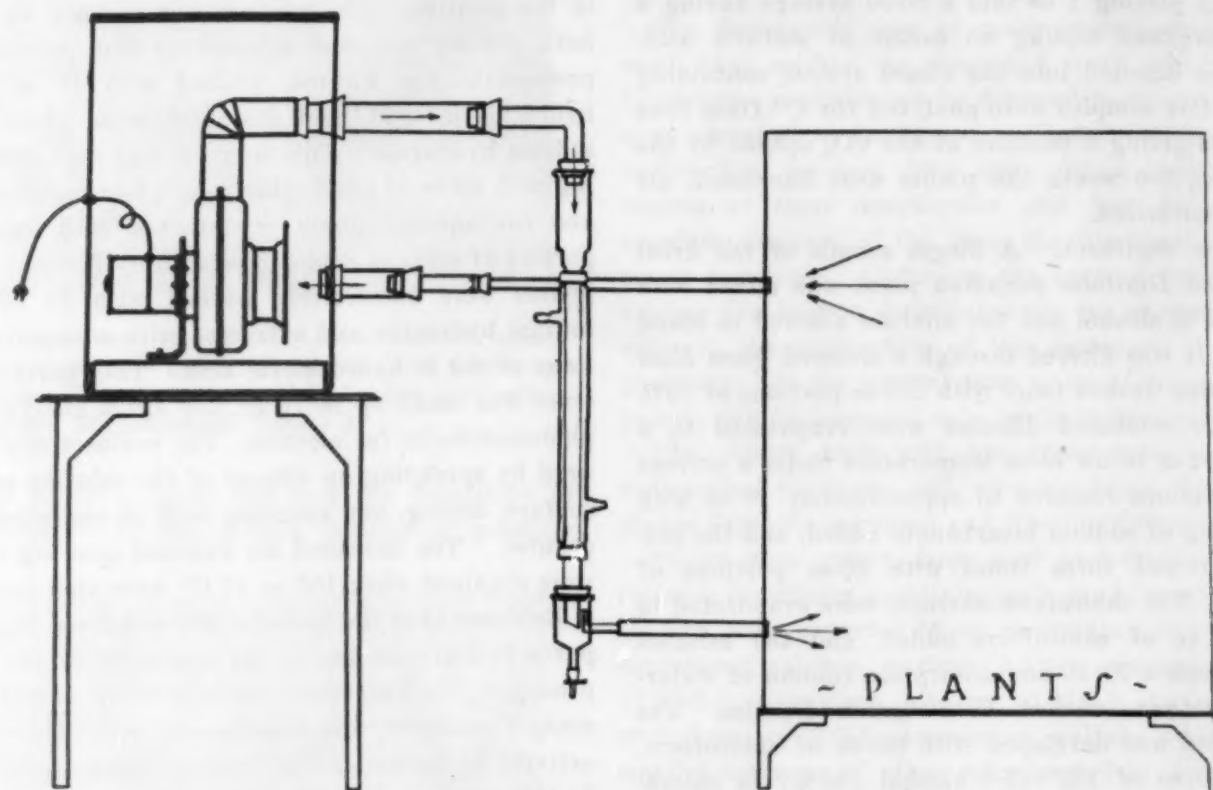


FIG. 1. Drawing illustrating blower-condenser unit with blower-motor housed in battery jar (left) and terrarium (right). The water condenser is connected between the exit of the blower unit and the entrance to the terrarium.

Excess moisture in the atmosphere of the terrarium was considered as one of the major factors detrimental to their growth. Consequently, a device for controlling the excessive humidity was devised. The necessity of preventing loss of any $C^{14}O_2$ from the terrarium required the

construction of an air-tight unit such as that illustrated in Fig. 1.

It consists of a motor-driven blower³ housed in an air-tight 9"×12" battery jar covered with a circular piece of glass plate and sealed with a 50/50 mixture of beeswax and rosin. Moisture-laden air is drawn from the terrarium, through the motor-blower, into a condenser and thence back into the terrarium, the excess moisture

being condensed and the condensate being collected and drained off from the bottom of the unit.

Employing this blower-condenser unit, we have been able to grow radioactive *Digitalis lanata* in sufficient quantities and with radioactivity of desired intensity.

The Production of Unilateral Epileptiform Convulsions From Otherwise Quiescent Foci by the Administration of Benzedrine

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Ruch (5) has recently reported the sedative effect of cerebral excitant drugs on hyperactivity in macaques with prefrontal lesions. The effect of this class of drug in changing the behavior resulting from cortical insult suggested to us that latent characteristics of a surgically-altered nervous system might be elicited by changing its

chemical environment. The consequences of an investigation of this possibility justify a preliminary report of the occurrence of unilateral Jacksonian seizures following administration of benzedrine (amphetamine sulfate) to an immature male macaque with symmetrical bilateral prefrontal removals.

This animal was acquired in October 1946 and was trained to mastery of the following problems: (a) visual spatial delayed response to a criterion of 90% correct at 30 sec, (b) auditory discrimination between a bell and a buzzer to a criterion of 90% correct, and (c) auditory delayed response to a criterion of 90% correct at 12 sec. The preoperative period of observation of approximately 6 months revealed no unusual physiological or behavioral characteristics. On May 7, 1947, a bilateral removal of

¹ Supported by the Life Insurance Medical Research Fund.

² Research assistant, Life Insurance Medical Research Fund.

³ Delco Appliances, General Motors Corporation. (115 volts, 60 cycles, 40 watts, 0.45 amps.)

prefrontal cortex was made on this animal, the lesion including all tissue anterior to a plane 5 mm in front of the arcuate sulcus on the dorsal surface and about 2 cm in front of the optic chiasm on the orbital surface. Recovery was uneventful. In the three days immediately following operation, the remarkable increase in locomotor progression characteristic of prefrontal macaque preparations developed gradually to its peak. Tests given 10-14 days postoperatively showed perfect retention of the auditory discrimination habit, but only chance scores on the visual and auditory delay problems. Considerable formal training in the subsequent months did not improve his performance. The monkey was kept under observation and almost daily trained and tested for 14 months following the operation. Throughout this period the activity level remained high, but no behavior suggestive of Jacksonian fits or epileptoid seizures was observed.

On July 19, 1948, at 10:00 A.M., he was given 6 mg of benzedrine by subcutaneous injection (his weight at this time was 8 lbs). Activity continued as before dosage, but food given was not swallowed, remaining in the food pouch. Twenty minutes later he was given 4 mg additional (the total amount given being about half the minimum lethal dosage, 1). During the next 40 min greatly increased activity, muscular incoordination, attacks on the cage walls, and general violence, but no convulsions, were noted. This condition was followed by prostration. He was then given 30 mg of Nembutal intraperitoneally. In the afternoon he was sitting up and moving about quietly. Partial paralysis of the left limbs, affecting the arm more than the leg, was observed. The right limbs appeared weak and uncoordinated. At 6:30 P.M. he was again prostrate and started having Jacksonian-type seizures, beginning with the corner of the mouth and spreading to the hand, arm, trunk, and leg of the left side. At no time in any convulsion did the clonic movements spread to the right side of the body. Later the convulsions started from the ear and were followed by adverse head movements and progressive involvement of the left limbs and trunk. At 7:15 P.M. the convulsions were starting with the adverse head movements. Each seizure lasted about 40 sec with about a 5-min interval between seizures. This interval gradually decreased until at about 8:00 P.M. the convulsions were coming every 2 min. In all, about 30-40 convulsions were observed. At 8:20 P.M. he was given 60 mg of Nembutal intraperitoneally, and the convulsions stopped within 5 min. Twenty minutes later convulsions again started, and he was given another 60 mg of Nembutal in two doses in the next hour and 105 mg more at 11:30 P.M. At 3:30 A.M. the animal was awake, prostrate, and quiet, and remained this way until evening. During the morning following he was given saline solution subcutaneously, and in the afternoon he drank a cup of orange juice and ate two pieces of fruit. That night he was sitting up, capable of movement but quiet and unresponsive. The paralysis and weakness were somewhat alleviated, but the left side was still less efficient than the right. The next morning he had regurgitated

all the food previously eaten and appeared very weak and stuporous, lying down much of the time. Late that afternoon he was sacrificed and perfused with 10% formalin. The brain was removed 48 hrs later. There was no hemorrhage or other gross abnormality which could account for the severe symptoms following the administration of benzedrine. There was scar tissue of about 2-3 mm in extent in the anterior part of the remaining frontal cortex on both sides.

It has been suggested by Hebb and Penfield (2) that maximum physiological and behavioral dysfunction may result from pathologically functioning tissue rather than from lack of tissue *per se*. Further, Penfield and Erickson (4) have localized adverse seizures, similar to the type described here, in the cortex of the frontal lobe immediately in front of the sensorimotor area. Kopeloff, *et al.* (3) have shown that a focus of irritation in the cortex produced by local application of a disc containing certain inactive materials may fail to cause seizures until sensitizing agents such as alumina cream are introduced parenterally. Our findings indicate that (a) irritative lesions, though insufficient to produce epileptic discharge, may be present after cerebral excisions; (b) benzedrine may increase sensitivity to these irritative effects; and (c) observed abnormalities of behavior, such as hyperactivity and failure in the delayed response test, following brain lesions may be due to the irritative action of pathological tissue which is subliminal for fits.

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The Pharmacological Properties of Some 2-Substituted-4-hydroxymethyl-1,3-dioxolanes¹

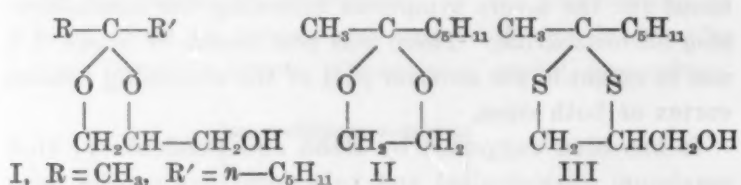
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Certain simple monoethers of glycerol were recently shown to cause a transient paralysis of the voluntary skeletal muscles without embarrassment of respiration (2). In smaller doses these substances had a controlling influence on various types of tremors and other involuntary movements, as well as a relaxing effect on spasm, spasticity, and rigidity (1, 3-6). The purpose of this

¹ Aided by a grant from the National Foundation for Infantile Paralysis.

note is to show that these characteristic effects of the glycerol ethers on the central nervous system are also present in another series of compounds of quite different structure, the 2-substituted-4-hydroxymethyl-1,3-dioxolanes (e.g. I).



Preliminary examination of over 50 compounds (most of them new²) in this series showed that the type of physiological action obtained was markedly influenced by the groups in position 2. Some of the 2-alkyl and 2,2-di-alkyl derivatives possessed a type of action similar to that of the monoethers of glycerol. Large doses of the active compounds caused complete muscular paralysis with a decrease of muscle tone. Spontaneous respiration and certain reflexes such as the knee jerk and wink reflex were maintained, even during profound paralysis. Small doses, which did not cause any detectable changes in the behavior and appearance of the animals, protected them from the effect of lethal doses of strychnine and Metrazol.

This paralyzing action appeared to be optimal if a total of 6-8 carbons was attached at position 2; the lower, water-soluble members of the series, and the higher, virtually water-insoluble members, were almost completely inactive. The compounds where R was methyl and R' a straight-chain alkyl group of 5-7 carbon atoms were found definitely superior to those with a different combination of groups, even when the total number of carbons on the 2-position was constant. It is interesting to note that the substitution of a cyclohexyl group for the *n*-amyl or *n*-hexyl (I, R = CH₃, R' = cyclohexyl) group decreased the activity sharply. Compounds in which R and R' were part of a carbocyclic ring, i.e. derivatives of cyclopentanone and cyclohexanone, showed some paralyzing activity, but less than those in which R and R' were alkyl groups.

The presence of the free hydroxyl group seemed to be essential for activity. The removal of the hydroxyl, as in II, or the acetylation of the hydroxyl of I abolished, or very markedly decreased, the paralyzing activity. The dithiolane III, analogous to I, was also inactive, as were the two examples of 2-substituted-4-hydroxymethyl-1,3-dioxolanes examined which contained a basic nitrogen atom. Compounds of formula I where R was alkyl and R' was aryl or heterocyclic also possessed interesting pharmacological properties. Some of these compounds caused paralysis, whereas other closely related compounds caused tremors, hyperexcitability, and convulsions.

The dependence of the activity and toxicity on the size and nature of the alkyl groups in position 2 is illustrated in Table 1, which gives the mean paralytic and mean lethal doses of a few of the alkyl substituted compounds examined. (The dose which caused a loss of the righting

² We are indebted to J. Figueras, C. G. Krespan, L. Libermann, and F. C. Pennington for their work on the synthesis of these compounds. We are also indebted to R. Plato Schwartz, M.D., for his interest in this work.

reflex in 50% of the animals was taken as a measure of the relative activity of the compounds and was called the mean paralytic dose.) The table also gives the comparable values for myanesin (*o*-toloxy-1,2-propanediol), the best compound of the glycerol ether series. It will be noted that certain members of the dioxolane series possessed greater activity and a greater margin of safety than myanesin.

TABLE 1

MEAN PARALYZING AND MEAN LETHAL DOSES OF CERTAIN 2-SUBSTITUTED-4-HYDROXYMETHYL-1,3-DIOXOLANES AFTER INTRAPERITONEAL ADMINISTRATION TO WHITE MICE

Formula I	PD ₅₀ ± SE*	LD ₅₀ ± SE*	LD ₅₀ /PD ₅₀
R R'	(mg/kg)	(mg/kg)	
<i>n</i> -C ₅ H ₁₁ <i>n</i> -C ₅ H ₁₁	205 ± 24	730 ± 69	3.6
<i>i</i> -C ₅ H ₁₁ <i>i</i> -C ₅ H ₁₁	155 ± 33	730 ± 73	4.7
<i>n</i> -C ₆ H ₁₃ H†	153 ± 23	430 ± 53	2.9
CH ₃ <i>n</i> -C ₅ H ₁₁	105 ± 24	500 ± 31	4.8
CH ₃ <i>s</i> -C ₅ H ₁₁	190 ± 30	475 ± 56	2.5
Myanesin	180 ± 20	500 ± 43	2.8

* PD₅₀ = mean paralyzing dose; LD₅₀ = mean lethal dose; SE = standard error.

† This compound may have the 1,3-dioxan structure, which is a 6-ring isomeric with structure I. This structure has been excluded for the other compounds.

Certain compounds mentioned in this preliminary communication may be useful as tools in neurophysiological research; others have potential therapeutic application.

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A New Treatment of Viscosimetric Data¹

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An interesting relationship exists in flow data secured from capillary-tube viscometers. To illustrate, Fig. 1 contains the flow data for several liquids obtained with a capillary-tube viscometer in which driving pressures were accurately controlled and expressed in millimeters of water. No kinetic energy corrections were applied. All of the flow lines look like those to be expected from such a study: they are logarithmic in type.

When two fixed pressures are chosen, as was done for Fig. 2—namely, at 100 and 500 mm of water pressure—and the two points for each liquid joined to form "two-

¹ This work was supported by the Johnson Research Fund of Northwestern University Medical School and the Evanston Hospital.

Effect of Chemical Treatment Prior to Storage on Viability and Growth of Cottonseed

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Cottonseed having a moisture content of 8-11% can be stored without loss of viability (8) for periods as long as two years in most sections of the United States. Seed with a moisture content of 12% or above, however, present storage difficulties which depend on the climatic conditions existing in the locality in which they are stored. Investigations at the Southern Regional Research Laboratory on the applicability of chemical treatment in preventing or minimizing heating and deterioration of moist seeds stored in bulk prior to processing for oil and meal have demonstrated that a number of chemicals of various types are effective (1-5) for these purposes. Among these chemicals are propylene glycol dipropionate (PGDP) and 4,6-bis-chloromethyl xylene (DCB) (6).

It was of interest to determine whether these compounds could also be used to prevent loss of viability during storage of moist seed, and accordingly they were investigated separately and in mixtures. The preliminary results of storage experiments using a mixture of these two compounds are reported in this publication. A more detailed report will be presented at a later date.

A Stoneville 2B variety of cottonseed, harvested in 1946 and having an initial moisture content of 8.9% and a germination count of 92%, was artificially conditioned to a moisture content of 12%, as described in a recent publication (7). The conditioned seed was divided into three equal lots. The first lot was untreated and served as the control; the second was treated with 0.28% (based on the dry weight of the seed) of a solution of DCB in PGDP, in the ratio of 1:8 by weight; the third was treated with 0.14% of the same solution. All three lots of seed were stored individually in screw-top glass jars of 1-gal capacity which were maintained at room temperature in the dark. Samples of 50 seeds were withdrawn from each jar for the determination of germination counts and seedling growth at 30-day intervals over a period of 6½ months. Germinations were carried out by the standard blotter technique at room temperature, and the counts were recorded for 4-day-old seedlings. Growth measurements of various parts of all seedlings that germinated were made at intervals up to 12 days. During this period the seedlings were sup-

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² The authors take this opportunity to thank Miss Claire Lesslie, of the Analytical Division of this Laboratory, for the analytical results reported here. The authors are also indebted to Dr. Marshall Kulka, Dominion Rubber Company, Guelph, Ontario, and to the Kessler Chemical Company for furnishing the chemicals used in this investigation.

³ One of the laboratories of the Bureau of Agricultural and Industrial Chemistry, USDA.

point flow lines," an unexpected harmony becomes evident; extrapolation of these lines results in the establishment of a focal point. When other pairs of pressures are taken in the same way, other focal points are

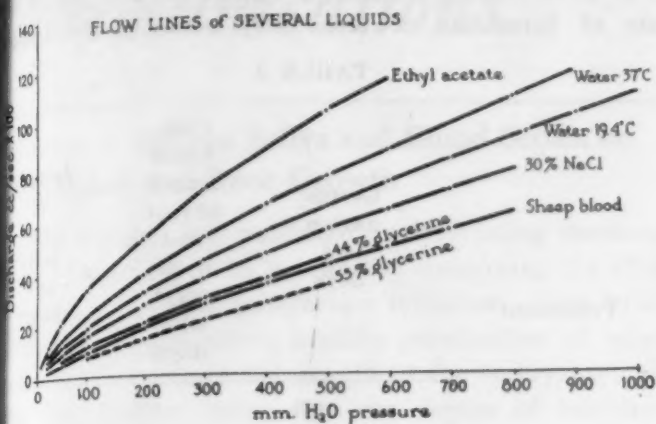


FIG. 1

established. All of these focal points appear to lie on a line passing through the origin.

Several valuable features arise from this observation. First, a given apparatus may be characterized by the slope of the line described by the focal points. Next, it is easy to determine whether a given liquid is flowing in a normal fashion. An example of an abnormally flowing liquid is blood: its two-point flow line does not reach the focal point established by normal liquids (Fig. 2).

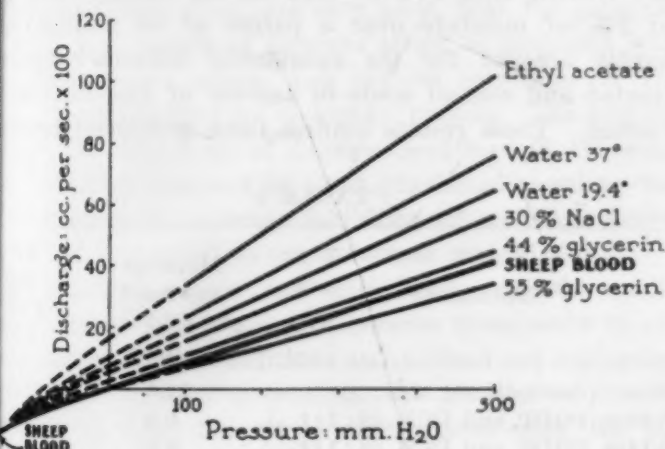


FIG. 2

Another advantage is that a single flow measurement will serve to define the whole logarithmic flow line of a normal liquid, since one point is already available in the focus and the curved line can be derived from the straight line thus determined.

The relationship described depends on the properties of the simple logarithmic curves traced by the flow lines. They belong to the type, $A \log X + B = \log Y$. These curves occur in families, each family with its own line of focal points passing through the origin if the treatment described above is applied. What seems remarkable is that normal liquids of a wide range of viscosity appear to flow through a given capillary in precisely the manner required to produce a group of flow lines that belong to a single family of logarithmic curves. A consideration of the known flow properties of normal liquids suggests that this is an effect to be anticipated.

ported individually in 20-ml glass bottles containing sufficient water to cover the roots and were exposed to artificial light in the laboratory.

The effects of the chemical treatment on the viability and seedling growth of cottonseed after 4, 5, and 6½ months of storage are listed in Table 1. It may be ob-

TABLE 1

Treatment*	Period of storage (months)	Germination in 4 days		Combined length of root and hypocotyl at 5 days		Length of hypocotyl at 7 days		Length of hypocotyl at 12 days	
		(%)	(% of control)	(mm)	(% of control)	(mm)	(% of control)	(mm)	(% of control)
Control	4	59	...	41	...	78	...	85	...
0.28% PGDP and DCB (8:1)	4	76	129	49	120	83	106	113	133
0.14% PGDP and DCB (8:1)	4	88	149	44	107	78	100	88	104
Control	5	48	...	70	...	75	...	90	...
0.28% PGDP and DCB (8:1)	5	66	138	100	143	92	123	130	144
0.14% PGDP and DCB (8:1)	5	84	175	87	124	85	113	115	128
Control	6½	52	...	50	...	36	...	65	...
0.28% PGDP and DCB (8:1)	6½	62	119	84	168	62	172	82	126
0.14% PGDP and DCB (8:1)	6½	70	135	73	146	60	167	85	131

* Based on the dry weight of the seed.

served from these data that the treatment with the mixed chemicals successfully maintained viability and growth at a level considerably higher than that of an untreated control under identical conditions of storage. The observed effects on growth appear to indicate the possibility that this compound has growth-promoting properties.

In addition to the above determinations of germination and growth, a sample of 1,000 seeds was taken from each of the jars of stored seed at the end of 6½ months of storage and germinated as previously described. The results of this test and the measurements made on the seedlings are shown in Table 2. The results obtained on this larger quantity of seeds confirm the trends observed with the smaller sample stored for the same length of time. It will be noted that the percentages of seeds germinating are given for the fourth day only. Experiments on this sample of seed have shown that it is not advantageous to continue tests using the blotter technique for a longer period of time. After four days the increases in the percentages of seeds germinating are very small, and, if the tests are permitted to continue, evidence of microbiological infection is observed. The results indicate that the treatments did not merely accelerate germination but actually resulted in a higher

percentage of germination over that of the untreated control.

An analysis of the samples after storage for 6½ months for moisture and free fatty acids is given in Table 3. It is clear that there was a significant decrease in the rate of formation of free fatty acids in the treated

TABLE 2

Treatment*	Germination in 4 days	Combined length of root and hypocotyl at 3 days		Length of hypocotyl at 7 days	
	(%)	(% of control)	(mm)	(% of control)	(mm)
Control	33	...	24	...	36
0.28% PGDP and DCB (8:1) ..	47	143	41	171	62
0.14% PGDP and DCB (8:1) ..	67	203	36	150	59

* Based on the dry weight of the seed.

samples. Despite the fact that the moisture content of the treated seed was reduced during storage, this loss of 2% of moisture over a period of 6½ months could hardly account for the substantial difference between treated and control seeds in amount of free fatty acid formed. These results confirm those previously reported

TABLE 3

Treatment	Moisture content* (%)	Free fatty acids (%)
None (control)	11.6	6.25
0.28% PGDP and DCB (8:1)† ..	9.8	1.48
0.14% PGDP and DCB (8:1)† ..	9.6	1.03

* According to the Methods of the American Oil Chemists Society (1947).

† Based on the dry weight of the seed.

(4) on the effect of the above-mentioned compounds in preventing free fatty acid formation during storage.

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Comments and Communications

Influence of Human Saliva and Blood Serum on Germination and Root Growth

Dvora Yardeni has published an interesting communication (*Science*, July 16, pp. 62-63) concerning the effect of human saliva as a germination inhibitor. That writer claims that human saliva inhibits germination of wheat seeds and particularly the growth of the embryonic radicle. She further states that the degree of inhibition caused by the saliva of the same individuals varied at different times, and that the inhibition of the radicle growth does not depend on sex or age. The present writer calls attention to the fact that pharmacological experiments on the germination of seeds and root growth of seedlings, studied on *Lupinus albus*, were made by him as early as 1922 and announced in 1923 (D. I. Macht and D. S. Lubin. *J. Pharm. exp. Therap.*, 1924, 22, 413). These experiments were performed in connection with studies on menstrual toxin. It was found that not only the saliva, but also the blood serum and various secretions of women in catamenia, are very toxic, both for germination and root growth of *Lupinus albus*, as compared with the saliva, blood serum, and various secretions of the same individuals between menstrual periods. The average root-growth inhibition of *Lupinus* seedlings in 1% solutions of saliva dissolved in plant physiological saline was 35%, whereas the average inhibition of seedlings grown in 1% of menstrual saliva solutions was 47%.

Much more accurate and scientifically reliable results were obtained with blood sera because these could be obtained under sterile conditions and without contamination of various elements present in the mouths of human beings. In fact, the above observations were the beginning of extensive researches on the subject of phyto-pharmacology, by the author and his co-workers, which have led to a number of important medical discoveries, particularly in connection with the diseases of pemphigus, pernicious anemia, leprosy, and trachoma (*J.A.M.A.*, 1927, 89, 753; *J. Invest. Dermat.*, 1947, 8, 171; *J. Philippine Islands med. Ass.*, 1928, 8, 523; *Folia Ophthalmol. orient.*, 1935, 1, 358; *Protoplasma*, 1937, 27, 1).

More recently, the writer has been engaged in studying the effect of blood sera on the respiration of the germinating seeds of *Triticum* (wheat) and *Avena* (oat) and has found that the toxins of menstruation, pemphigus, and other diseases definitely inhibit oxidation and reduction processes of such germinating seeds.

Kramer and Silberschmidt (*Science*, October 15, p. 40), commenting on the Yardeni article, suggest that perhaps growth hormones in the saliva may explain its inhibiting action on seed germination and root growth.

In this connection we call attention to the fact that the idea entertained formerly in regard to inhibition of

root growth by the growth hormones is no longer tenable. It was shown by Macht and Grumbein that the effects of indole acetic, indole butyric, and naphthalene acetic acids on roots of *Lupinus albus* seedlings depend on the concentration of the chemicals employed. Solutions up to one in one billion do inhibit growth. When, however, much less concentrated solutions of the hormones are used, there is actually a stimulation in root growth (*Amer. J. Bot.*, 1937, 24, 457).

On the basis of the writer's experiences, the inhibiting properties of saliva and blood sera may be more appropriately ascribed to some unknown toxin or toxic substance in those fluids rather than to a growth hormone.

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A New Organic Uranium Compound

A new organic uranium compound has been prepared from anhydrous uranium acetate and hexamethylene tetramine.

One hundred cc of an alcoholic solution of anhydrous uranium acetate was added at 24° C to 80 cc of an alcoholic solution of hexamethylene tetramine. The uranium solution contained 2.46% of acetate/100 gm of alcohol; the tetramine solution, 9.5 gm/100 gm of alcohol. The amine was therefore greatly in excess.

When the two solutions were mixed, a yellow ppt formed immediately. This was washed with hot alcohol, dried, and examined.

The substance showed needle-like crystals, decomposed at 185° C, and dissolved in glacial acetic acid, but was insoluble in alcohol. On analysis it gave U, 46.3; N, 9.7. [(UO₂) (Ac)₂ (CH₂)₆N₄ gives U, 45.02 and N, 10.5.]

Evidently the two components are present in the molecular ratio of 1:1.

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Dieyema paradoxum von Kölliker, 1849

The Mesozoa comprise one of the most controversial groups in the animal kingdom. The disagreement concerns their structure, life history, method of reproduction, and zoological status. The confusion arising from different interpretations of morphology and development is augmented by errors in nomenclature. Certain of these errors were rectified by Stunkard (*Amer. Mus. Nov.*, 1937, No. 908). Recently, study of the parasites of octopuses has necessitated a review of the literature on members of the family Dieyemidae.

The generic name *Dieyema* was selected by von Kölliker (*Ber. zoot. Anst. Würzburg*, 1849, 2, 59-66), since he first noted that these animals produce two distinct types of embryos, which he designated as "wurmformig" and "infusorienartig." The two kinds of embryos had been observed and described by Erdl (*Arch. Naturg.*, 1843, 9, 162-167), who regarded them as developmental stages of a single individual. Kölliker studied the parasites found

in *Octopus vulgaris* and *Octopus macropus* and identified all the dicyemids found by him and those described by previous authors from other cephalopods as members of a single species, for which he proposed the name *Dicyema paradoxum*. The genus, as erected, was monotypic and *D. paradoxum* is the type species. The observations and descriptions of von K  lliker appear remarkably accurate and complete when compared with zoological reports of a century ago.

Subsequent investigations, however, have shown that *D. paradoxum* of K  lliker was a complex of several species. Van Beneden (*Bull. Acad. Roy. Belg.*, 1876, 41, 1160-1205; 42, 35-97) restricted the genus *Dicyema* to parasites of octopuses; those from *O. vulgaris* were designated as *D. typus* and those from *O. macropus* as *D. clausianum*. The name *D. paradoxum* was omitted. Holding a view diametrically opposed to that of von K  lliker, van Beneden believed in absolute taxonomic correlation between hosts and parasites. New genera were erected for the dicyemid parasites of each genus of cephalopods other than *Octopus*, and the parasites of the several cephalopod species were regarded as distinct. In van Beneden's system the family Dicyemide consisted of 4 genera and 7 species. Species described by Wagener (*Arch. Anat. Physiol. wiss. Med.*, 1857, 344-364) were redescribed and renamed when assigned to the new genera. Whitman (*Mitt. zool. Stat. Neapel*, 1882, 4, 1-89) described additional new species and showed that van Beneden's idea of strict host-parasite specificity was erroneous; that the same species could infect more than one host species and that a single host could harbor more than one species of parasite. Whitman was meticulous in restoring names proposed by Wagener for species that had been renamed by van Beneden. He stated (p. 4): "... in systematic zoology the claims of priority are not to be superseded by those founded on accuracy of description." But van Beneden had also renamed the parasites described by von K  lliker as *D. paradoxum*, recognizing two species which he designated as *D. typus* and *D. clausianum*, respectively. Whitman accepted these names, and they have been adopted by subsequent authors. Nouvel (*Arch. Biol.*, 1947, 58, 59-220) stated: "Pour K  lliker, le genre *Dicyema* comprenait tous les Dicy  mides connus (*D. paradoxum*). Quand Whitman a cr  e un second genre (*Dicyemennea*), l'auteur a conserv  , pour l'un des genres, le nom de *Dicyema* car le description de K  lliker est pr  cis  ment fond  e sur deux esp  ces qui restaient dans le genre ainsi restreint." It is clear, therefore, that the name *D. paradoxum* must apply to one of the two species now known as *D. typus* and *D. clausianum*. In an earlier paper, Nouvel (*Bull. Soc. Hist. Nat. Toulouse*, 1946, 81, 169-174) redescribed *D. typus* as the smaller of the two species, with a smaller number of somatic cells (16-20), usually 18 or 19, and stated that in this species the diapolar cells never form pendant verruciform enlargements. According to Nouvel, *D. typus* occurs only in *Octopus vulgaris*, whereas *D. clausianum* occurs in both *O. vulgaris* and *O. macropus*. Moreover, Nouvel stated that earlier authors including van Beneden (1876), Whitman (1882), Hartmann (1906), Lameere (1914, 1916,

1918, 1919), and he himself in former papers, had identified individuals of *D. clausianum* as *D. typus*.

The International Code of Zoological Nomenclature provides that, if a species is divided into two or more restricted species, its valid name must be retained for one of the restricted species. Van Beneden (1876) did not admittedly divide the species *D. paradoxum*; instead, he redescribed the organisms as members of two distinct and restricted species for which he proposed new names, although both species were retained in the genus *Dicyema*. Indeed, they were the only species included in the genus. The procedure is clearly invalid, since the genus *Dicyema* is based on its type species *D. paradoxum*. Whitman and subsequent authors have perpetuated the error in accepting the two specific names proposed by van Beneden. Despite any disavowal, van Beneden virtually divided the species, and the name *D. paradoxum* must be retained for one of the restricted species which stands as type of the genus. As noted, either *D. typus* or *D. clausianum* must be relegated to synonymy. Since von K  lliker described and figured large individuals with prominent verruciform enlargements of the diapolar cells, it seems probable that his description applies more properly to the species called *D. clausianum* by van Beneden. Accordingly, *D. clausianum* van Beneden, 1876 is suppressed as a synonym of *D. paradoxum* von K  lliker, 1849.

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Enpony and Enchresy

There are 5 functions of great importance in thermodynamics: the energy, entropy, enthalpy, and the free energy functions of Helmholtz and Gilbert Lewis. The first two functions have no other names. The third was formerly called heat content, but the name enthalpy, from $\tau\omicron$ $\theta\alpha\lambda\pi\omicron\varsigma$ (heat), seems to win. Helmholtz free energy is a rather awkward name for a very useful function, and the matter was worse when Gilbert Lewis unfortunately used the term free energy for another still more useful function. The latter has also been called thermodynamic potential and Gibbs' function.

I think everyone who has been teaching thermodynamics or has written textbooks in physical chemistry has felt the need for not bigger, but better, names for the two last-mentioned functions. May I suggest that Helmholtz free energy, which measures the work obtainable from a system at a constant temperature, be called *enpony*, from \omicron $\pi\omicron\nu\omicron\varsigma$ (work). The system does part of this work against the pressure of the surroundings and in many processes, only the remainder (German *Nutzarbeit*) is utilized. This "useful work" is measured by Lewis free energy, which might be called *enchresy*, from η $\chi\rho\eta\omicron\iota\varsigma$ (use, utility). These new terms do not seem less euphonious than the three older ones, and they are not liable to cause any confusion.

ARNE   LANDER

University of Stockholm

Obituary

Alfred Church Lane

1863-1948

Alfred Church Lane, geologist, died in New York City on April 15, 1948. Dr. Lane was a quantitatively-minded natural scientist who thought in terms of lasting human values. In the best sense of the word he was a humanist-scientist. He was a New Englander of New Englanders, a devout church member, a rigorous natural scientist, an outstanding teacher. In his lively and complex nature he was a modern incarnation of the best in the Renaissance man. He was sensitive to new and emerging values but ever conscious of solid old truths. He was versatile in his skills and broad in his interests. As he spoke, he loved to let his mind range beyond the horizons and then bring his hearers back with a quick reinforcement by some common-sense and penetrating observation. He was trained in analysis, but his mind was truly synthetic.

Dr. Lane was born on January 29, 1863, in Boston. He was graduated from Harvard in 1883 and in 1888 received the Ph.D. degree from his Alma Mater. From 1885 to 1887 he was a student at the University of Heidelberg. In 1913 Tufts awarded him the honorary D.Sc. degree.

From 1883 to 1885 he was an instructor in mathematics at Harvard. This was a significant phase of his life, because in many of his later contributions to his own science of geology he thought and wrote with the tools of mathematics. He assisted in transforming parts of his chosen field from a purely qualitative and descriptive earth science to a modern and quantitative discipline closely related to physics and chemistry. From 1889 to 1892 Dr. Lane was petrographer of the Michigan State Geologic Survey and instructor in the Michigan College of Mines. From 1892 to 1909 he was, successively, assistant and state geologist of Michigan. In the latter year he became Pearson professor of geology and mineralogy at Tufts College and in 1936 retired as professor emeritus.

His honors and professional activities were many. In 1929 he became the first consultant in science ever appointed at the Library of Congress. Beginning in 1924 he was a member of the Board of Visitors of the Harvard Observatory. In 1940 Tufts College awarded him its Ballou Medal for distinguished service to education and the Nation. He served as vice-president

of the Division of Geology of the AAAS (1907) and as president of the Geological Society of America (1931), and held several offices in the American Academy of Arts and Sciences. For many years he was chairman of the important National Research Council Committee on the Measurement of Geologic Time. In connection with the work of this Committee he became active in the study of radioactive minerals.

Indicative of the all-round interests of this modern Renaissance man was his affiliation with many societies in fields other than geology—for example, those having to do with history, natural history, engineering, forestry, and astronomy. He was an honorary member of the Geological Society of Belgium. Three times he was an official delegate from America to international geological conferences. In World War I he was with the overseas YMCA and head of the Department of Mining of one of the emergency war colleges of France. For his long and ardent service to all phases of scouting he was awarded the Silver Beaver by the Boy Scouts of America.

Dr. Lane was the author, in German and English, of 1,087 publications.

As a college professor and department head at Tufts Dr. Lane had a remarkable influence upon more than a full generation of students. He had the rewarding privilege of teaching not a few of his old students' children when they in turn came to Tufts. He was always jealous of the high scientific character of his subject. Almost always he demanded that his students not only study geology itself but supplement it with a thorough knowledge of mathematics, physics, and chemistry. For this reason his many students who went on from Tufts to graduate schools were always equipped to deal with the quantitative geology of the future rather than merely with the descriptive geology of the past. The list of his former students who hold places of distinction in American scientific and university life is today a living tribute to his influence.

In his teaching, as in his life, he was perpetually youthful. He was always interested in the latest geological discoveries and in the current problems of the Nation and of the world. His scholarship and wide study were for him a solid starting platform from which to launch new but guided missiles into the unknown.

At all times as a citizen and a scientist he was ready to participate in the solution of problems facing so-

ciety. By his life and attitudes he gave us all a functioning model of the service that a citizen of a democracy can give to local, state, national, and, indeed, international governmental agencies.

Tufts College, the science of geology, our Nation

itself, and the cause of real international understanding have lost a dynamic figure in the death of Alfred Church Lane.

LEONARD CARMICHAEL

Tufts College

Book Reviews

Insects of Hawaii. (Vols. I-V.) Elwood C. Zimmerman. Honolulu: Univ. Hawaii Press, 1948. Vol. I: Pp. xx+206, \$3.50; Vol. II: x+475, \$5.50; Vol. III: 275, \$4.50; Vol. IV: 300, \$4.50; Vol. V: 500, \$6.00.

If there is anyone left who does not believe in evolution, I would recommend to him the study of the fauna of the Hawaiian Islands.

On 6 major and a number of minor islands that are nothing but the tops of a chain of volcanoes rising from the undisturbed ocean bottom, a most remarkable fauna has evolved. Perkins, the grand old man of Hawaiian natural history, published a set of volumes on the insect fauna of these islands between 1899 and 1913, but so much additional information has been gathered by subsequent investigators that the publication of a new insect fauna became imperative. Dr. Zimmerman has undertaken this Herculean task. The new *Insects of Hawaii* will comprise some 12-15 volumes, of which the first 5 have just been published. They cover the lower orders including Orthoptera and Hemiptera and contain the descriptions of 1,100 species, with notes on their origin, distribution, hosts, predators, and controls.

The introductory volume discusses the history of the islands which geologists believe to have originated not earlier than in the late Tertiary. This conclusion seems contradicted by the amazingly diversified fauna, with its numerous endemic genera and subfamilies indicating extreme age. Unsuspectedly rapid evolution, as well as colonization by endemics from now-submerged archipelagoes, may be the solution of this puzzling contradiction.

Zimmerman shows that transoceanic dispersal is much greater in some groups of insects than was believed possible by earlier authors. There is no need to postulate former land bridges for which there is no geological evidence. The total insect fauna of Hawaii, consisting of more than 3,700 endemic species, seems to have descended from 233-254 original colonizations. About 95% of the endemics have Pacific affinities, and only 5%, American.

The extreme isolation of the islands permitted the evolution of a unique microcosmos. Aberrant species occur in every family, often exceedingly bizarre, but close study invariably reveals that they are members of some orthodox group. The most remarkable is perhaps a damselfly, the larvae of which have given up the usual aquatic habits of this family and live in the litter of the forest floor. Such cases demonstrate graphically how new higher categories may originate.

It would lead too far to report on even a fraction of the many interesting biological phenomena discussed by

Dr. Zimmerman. They include topographic isolation, the polyphyletic origin of flightlessness, of predacity and parasitism, rates of evolution, extinction, and many ecological phenomena. The Bernice P. Bishop Museum, the Hawaiian Sugar Planters' Association, and the University of Hawaii are to be congratulated on having sponsored this important publication.

ERNST MAYR

American Museum of Natural History, New York City

Proteins and life. M. V. Tracey. London: Pilot Press, 1948. Pp. x+154. (Illustrated.) 10/6.

This little book, by a member of the Department of Biochemistry at the Rothamsted Experimental Station, provides an excellent brief account of the fundamentals of protein chemistry. It is well written and is characterized by clearness of statement and simplicity of presentation. The details of methods are for the most part omitted, although references to the original literature are provided for those who wish to go more deeply into a particular subject. References to review articles and other collateral material are also given. The book thus may well serve as a point of departure for the student of biochemistry at the undergraduate or graduate level. It can be read with profit even by those who have specialized in the study of proteins.

The first few chapters deal with the nature of proteins, their composition, and the more important present-day views on protein constitution. Chapters on proteins in nutrition, in industry, as components of living tissues, and as factors in disease follow. The factual information is well chosen and, in general, accurate; few errors having been detected. A valuable feature, especially for the beginning student, is the summarization of information into brief tabular statements after each section.

The reviewer questions the use of the technical term "residue" on page 19 and elsewhere. In American practice, at least, the residue of an amino acid is the part remaining when the hydroxyl group of the carboxyl and one hydrogen of the amino group are removed. The author appears to have confused residue with radical. On page 25 the essential role of the peptidases in completing the enzymatic hydrolysis of a protein is overlooked, although the matter is made clear subsequently. Despite such minor and fortunately rare imperfections as this, however, the book can be highly recommended.

H. B. VICKERS

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NEWS

and Notes

President Truman's Thanksgiving Day Proclamation—"As the traditional day of Thanksgiving approaches, our thoughts incline, as in previous years, to the richness of our blessings. The spiritual endowments of our country are undiminished; we, as always, walk as free men unafraid. Our harvests have been bountiful, our production of goods abundant. Our resources have permitted us to aid the needy and helpless of other lands.

"We are privileged to participate in international efforts to advance human welfare. We are profoundly grateful for the existence of an international forum where differences among nations may be submitted to world opinion with a view to harmonious adjustment.

"We pray this year not only in the spirit of thanksgiving but also as supplicants for wisdom in our approach to the problems confronting this nation. Believing in the dignity of man and his right to live in freedom and peace, we ask divine guidance in helping to safeguard these gifts for ourselves and other peoples of the earth.

Now, therefore I, Harry S. Truman, President of the United States of America, in consonance with the joint resolution of Congress approved December 26, 1941, designating the fourth Thursday of November in each year as Thanksgiving Day, do hereby proclaim Thursday, November 25, 1948, as a day of national thanksgiving; and I call upon our citizens to observe that day by giving thanks to Almighty God for the bounties which have been bestowed upon our nation and by resolving to render generous assistance to the hungry and homeless of other lands, thus renewing our devotion to the cause of good-will among men."

About People

Frans Verdoorn, managing editor of *Chronica Botanica*, has assumed his new duties as director of the Los Angeles State and County Arboretum

at Arcadia, California. The 117-acre Arboretum is operated by the California Arboretum Foundation, Inc., a nonprofit organization which is planning the development of a modern arboretum and botanical garden with various research and educational departments. Dr. Verdoorn will continue to edit *Chronica Botanica* and related serials.

Arthur F. Hooper, formerly of Northwestern University, and **William Hovanitz**, formerly of the University of Michigan staff, were recently appointed assistant professors in the Biology Department at Wayne University.

Albert F. Blakeslee, of the Genetics Experiment Station, Smith College, is also serving as visiting lecturer at Harvard University during the current semester. Dr. Blakeslee is giving the course in genetics.

Paul C. Cross, chairman of the Department of Chemistry, Brown University, has been appointed head of the Department of Chemistry and Chemical Engineering at the University of Washington, Seattle. His appointment will become effective July 1, 1949.

Edward H. Berger, chemist and authority on asphalts, tars, and pitches, has been awarded the honorary D.Sc. degree by Franklin and Marshall College. The industrial scientist is an honor graduate of the College, Class of 1915.

Arthur F. Coca, editor of the *Journal of Immunology* since it was founded in 1916, has resigned and will now serve as associate editor. His successor is **Geoffrey Edsall**, director of the Antitoxin and Vaccine Laboratory of the State of Massachusetts.

Edwin A. Lawrence has been named professor of surgery (oncology) and director of the Cancer Teaching Program in the College of Medicine, University of Utah. Dr. Lawrence, who has been in private practice in Salt Lake City, was formerly director of the Tumor Clinic at Yale University.

John A. Toomey, director of the Contagious Disease Department, Cleveland City Hospital, and professor of clinical pediatrics and contagious dis-

eases at Western Reserve University School of Medicine, is on sabbatical leave. He is replaced by **Morris Schaeffer**, who is acting director of the Department and assistant professor of pediatrics at Western Reserve.

Paul J. Flory, who has been in charge of fundamental research at the Goodyear Research Laboratory in Akron, Ohio, since 1943, has joined the Cornell University staff as professor of chemistry.

Russell S. Poor, dean of the Graduate School of Alabama Polytechnic Institute, will join the Oak Ridge Institute of Nuclear Studies about January 1 as chairman of the University Relations Division. In this post Dean Poor will be in charge of the graduate training and research participation programs, two of the Institute's most important activities.

O. Wilford Olsen, formerly parasitologist with the U. S. Bureau of Animal Investigations, has been appointed professor and head of the new Department of Zoology, Colorado A & M College, Fort Collins. Joining Dr. Olsen on the staff are **Tylar A. Woolley**, formerly of Ohio State University, and **Richard G. Beidleman**, formerly of the University of Colorado, both of whom have been made assistant professors.

Grants and Awards

The Sterling-Winthrop Research Institute, together with Winthrop-Stearns, Inc., has awarded a total of 52 grants-in-aid, valued at \$159,644, so far this year. According to a joint announcement by Maurice L. Tainter, director of the Institute, and Justus B. Rice, vice-president in charge of medical research, Winthrop-Stearns, 24 of the grants were awarded to universities, medical schools, and colleges, with the balance going to clinics, hospitals, institutes, research foundations, and individuals. The general grants are supporting investigations and training in therapeutics, pharmacology, neurosurgery, internal medicine, organic chemistry, and related fields. Specific grants were awarded for research in such subjects as anti-sepsis, anesthesia, chemotherapy, metabolism, antimalarials, asthma, treatment of heart conditions, etc.

Illinois Institute of Technology has received two research grants from the Research Corporation of New York. Samuel Siegel, assistant professor of chemistry, was granted \$4,000 for his research on stereochemistry of displacement reaction, and August J. Durelli, research engineer of the Armour Research Foundation, \$2,500 for his research on brittle material method of experimental stress analysis.

Kenneth M. Watson, engineering consultant and professor of chemical engineering at the University of Wisconsin, is the recipient of the 1948 William H. Walker Award of the American Institute of Chemical Engineers. The award was made to Dr. Watson during the recent annual meeting of the Institute for his many important publications in the chemical engineering field.

The new betatron project at the University of Illinois College of Medicine (see *Science*, June 25, p. 676) will be implemented by a grant of \$20,000 just awarded by the American Cancer Society, Inc., to the College. The grant is to be used for the purchase and manufacture of accessory instruments required for accurate operation of the 20,000,000-volt betatron. Its delivery to the University this month will mark the world's first installation of this type of machine for cancer treatment and research.

Nine grants totaling \$82,688 in support of laboratory and clinical research in cancer have just been approved by the U. S. Public Health Service. These go to: the University of San Francisco, \$3,272 for the synthesis and microbiological evaluation of amino acid analogues; Michael Reese Hospital, Chicago, \$12,000 for study of nutritional factors in the origin and growth of tumors; the University of Illinois, \$11,448 for study of the formation of jaw tumors in a known strain of rats; Indiana University, \$7,560 for a study of factors influencing abnormal development in mammals; Tulane University, \$18,576 for a study of the relationship of hormones to neoplasia; Smith College, \$4,752 for studies of tumors in plant embryos; the University of Missouri, \$10,000 for work in skin cancer in mice and men; the University of Virginia,

\$11,880 for studies of blood in cancer patients; and the University of Wyoming, \$3,200 for work on the effect of deuteron bombardment on the chemical composition and carcinogenicity of organic compounds.

The Cranbrook Institute of Science, Bloomfield Hills, Michigan, announced on November 10 the awarding of the third Mary Soper Pope Medal to William Vogt, chief of the Conservation Section, Pan American Union, for his important studies of populations and natural resources of Latin-American countries and for his best-selling book, *Road to survival*. The Medal is given for noteworthy and distinguished accomplishment in plant science without restriction as to field of plant science and without limitation as to the geographic position, nationality, race, creed, or position of the recipient. In awarding the Medal for distinguished accomplishment in plant science to an ecologist who is most widely known as an ornithologist, the Institute has announced that it is in no manner violating the purposes of the donor of the Medal. It is, rather, "recognizing Mr. Vogt's own thesis, that the renewable natural resources—the forests and the grasslands, the soils, the waters on the land, wildlife, and human well-being—are inextricable strands of one whole natural fabric."

Colleges and Universities

The Laboratory for Nuclear Science and Engineering, Massachusetts Institute of Technology, has begun construction of a 12,000,000-volt electrostatic generator to bombard the nuclei of atoms at voltages several times higher than those produced by existing machines of its type. According to Dean George R. Harrison, atomic particles accelerated in the new generator will have sufficient energy to penetrate and break up even the heaviest atomic nuclei. A unique feature of the machine is that the energy of these fast-moving electrified particles will be readily variable from zero to maximum voltage to cover a wide range of experimental requirements. An outgrowth of the original generator designed in 1933 by Robert J. Van de Graaff, of the Institute's Department of Physics, the new ma-

chine has been developed largely through the researches of John Trump and his associates in the Department of Electrical Engineering.

In addition to nuclear research, a new generator will be used for studying the biological effects of high energy radiation on living and non-living matter. These studies include the effects of radiations inactivating bacteria, viruses, and enzymes, as well as their use in treating malignancies.

A new publication of the Division of Science at Iowa State College made its appearance early this month. *The Iowa State Scientist*, which is edited and produced by students in the Division, presents a popularized version of science.

The Detroit Institute for Cancer Research has become formally affiliated with the College of Medicine, Wayne University, according to a recent joint announcement. Appointments to the scientific staff of the Institute will be made upon recommendation of its scientific director together with the endorsement of the University faculty. The dean of the College, or his representative, will be a member of the executive committee of the board of trustees of the Institute; and the scientific director of the Institute, or his representative, will be a member of the administrative committee of the College. Officials of the two institutions hope that the affiliation will bring national support on a wider basis than was before possible. Each agency will, in addition, have greater resources in terms of personnel and equipment on which to draw.

Meetings and Elections

The Sixth Annual Plains Archaeological Conference will be held November 25-27 in the University of Nebraska Laboratory of Anthropology. The November 25 program will include a roundup of archaeological investigations in the Central Plains during the past year, a report on the activities of the Missouri Valley River Basin Survey of the Smithsonian Institution by W. R. Wedel, and a report of the Committee on Pottery Typology by C. Spaulding, University of Michigan.

J. D. Jennings, University of
The session on the 26th will be
to aspects of evidences of cli-
change during postglacial times,
W. D. Strong, Columbia Univer-
acting as chairman. Ernst An-
Carnegie Institution, Paul B.
Oberlin College, and Fred Eg-
University of Chicago, will pre-
papers. The November 27 morn-
session with discussions of climate,
environment, and culture will be under
chairmanship of Dr. Wedel. G. F.
Ill, of Bismarck, North Dakota, H.
Weakly, of the U. S. Field Station,
Well, South Dakota, and H. M.
Morrington, of the Colorado Museum
Natural History, Denver, will pre-
papers. The afternoon session
will feature a special round-table dis-
cussion on climate and the age of
various Plains culture horizons, with
H. H. Roberts, Jr., Bureau of
American Ethnology, Smithsonian In-
stitution, acting as chairman.

At the meeting of the American
Society of Mechanical Engineers, to
be held in New York City November
4-December 5 (see *Science*, October
1948, p. 469), Section M (Engineering)
the AAAS will sponsor jointly with
the ASME the following programs:
November 29, 8:15 P. M., Applied
Mechanics III; November 30, 9:30
A. M., Heat Transfer IV and 2:30
P. M., Heat Transfer V; December 1,
9:30 A. M., Heat Transfer VI and
2:30 P. M., Applied Mechanics VIII;
December 2, 9:30 A. M., Applied Me-
chanics IX and 2:30 P. M., Aviation
III; December 3, 9:30 A. M., Prop-
erties of Gases I.

Stanley S. Ballard, chairman of
the Department of Physics at Tufts
College, was elected a vice-president
of the International Commission of
Optics (an affiliate of the Interna-
tional Union of Pure and Applied
Physics) at the ICO meeting held in
Delft, Holland, in July.

The 16th annual meeting of the
ACFAS (Association canadienne-
française pour l'Avancement des
sciences) was held October 10-11, in
Quebec City, Canada. Lionel Lemay,
general secretary, reports that papers
were presented in the Physics, Chemis-
try, Geology, General Biology, Ecol-
ogy, Botany, Agronomy, Entomology,
Psychology, Geography, and History

Sections. A symposium was held on
the coordination of the scientific train-
ing between French-Canadian colleges
and universities, a report of which will
be published shortly. Léon Lortie,
professor of chemistry and of the
history of science, University of Mon-
treal, was elected president; Lionel
Davault, director of the Provincial
Laboratory of Entomology, Quebec,
and Ignace Brouillet, director of the
Ecole Polytechnique, Montreal, 1st
and 2nd vice-presidents, respectively;
and Lionel Lemay, professor of chem-
istry, University of Montreal, general
secretary.

The Connecticut Academy of Arts
and Sciences on October 21 elected
its officers for the year 1948-49.
They are: E. R. Goodenough, presi-
dent; G. H. Hamilton, V. L. Loosanoff,
and H. Margenau, vice-presidents;
Dorothea Rudnick, secretary; L. G.
Tighe, treasurer; and J. T. Babb, li-
brarian. Offices of the Academy are
at 701 Sterling Tower, Yale Univer-
sity.

NRC News

Fellowships in the Medical Sci-
ences, similar to those which have been
administered by the Medical Fellow-
ship Board of the National Research
Council since 1922, will again be avail-
able for the year 1949-50. Supported
by grants from the Rockefeller Foun-
dation to the NRC, they are designed
to provide opportunities for training
and experience in research in all
branches of medical science. They are
open to citizens of the United States
or Canada who possess an M.D. or a
Ph.D. degree and are intended for
recent graduates who are not yet pro-
fessionally established.

In addition, the Medical Fellowship
Board administers two groups of re-
search fellowships, made available
through a grant from the National
Foundation for Infantile Paralysis,
Inc. The first group, open to appli-
cants who hold either the Ph.D. or
M.D. degree, is for the purpose of
providing opportunities for special
training and experience in the study of
virus diseases. The second group, open
only to graduates in medicine who have
completed one or more years of hos-
pital experience in clinical surgery and
are planning a career in orthopedic

surgery, is designed to provide oppor-
tunities for training and research in
those basic medical sciences which will
be of particular value in furthering
progress in the field of orthopedic
surgery.

A series of fellowships in anes-
thesiology, established through a grant
from the American Society of Anes-
thesiologists, are offered with a view
to fostering a closer union between
the clinical practice of anesthesiology
and the fundamental disciplines on
which anesthesia rests. Applicants
must hold the M.D. degree and must
have completed one or more years of
hospital experience as intern or resi-
dent.

The Medical Fellowship Board has
also under its jurisdiction a number of
fellowships of senior grade in internal
medicine (Welch Fellowships), epi-
demiology, clinical neurology, ortho-
pedic surgery, pediatrics, and virus
diseases, for individuals of proven re-
search ability.

Fellows will be appointed at a meet-
ing of the Medical Fellowship Board
early in March 1949. Applications to
receive consideration at this meeting
must be filed on or before December
1, 1948. Appointments may begin on
any date determined by the Board.

For further particulars concerning
these fellowships, address the Secre-
tary of the Medical Fellowship Board,
National Research Council, 2101 Con-
stitution Avenue, N.W., Washington
25, D. C.

AEC Postdoctoral Research Fel-
lowships in the Medical Sciences will
also be available for the year 1949-
50. These fellowships, administered
for the Atomic Energy Commission by
the National Research Council, are de-
signed to provide advanced basic
training and research experience for
men and women entering upon careers
in fields related to atomic energy.
Any field of the medical sciences in
which nuclear phenomena are involved
is open to applicants.

A fellow must be a citizen of the
United States and under 35 years of
age at the time of appointment. He
or she must have had training in some
branch of the biological or medical
sciences equivalent to that represented
by the M.D. or Ph.D. degree and must
have demonstrated ability for research.
To be eligible for these awards, physi-

cians must have completed at least one year of internship. In exceptional cases, work equivalent, in the opinion of the Board, to that of an internship may be accepted as fulfilling this requirement.

Fellows will be appointed at a meeting of the AEC Postdoctoral Fellowship Board in the Medical Sciences in March 1949. Applications to receive consideration at this meeting must be filed on or before December 1, 1948. Appointments may begin on any date determined by the Board.

Further particulars may be obtained from the AEC Postdoctoral Fellowship Board in the Medical Sciences, National Research Council.

Deaths

William Gerard Beckers, 74, manufacturing chemist, died in his New York City home November 3. Dr. Beckers founded the Beckers' Aniline and Chemical Works, a forerunner of the National Aniline and Chemical Company, Inc. Later National Aniline became a division of the Allied Chemical and Dye Corporation, for which Dr. Beckers acted as a director until his death.

William Harvey Emmons, 71, professor emeritus of geology and mineralogy at the University of Minnesota, died November 5 at his home in Minneapolis. Dr. Emmons served as head of the Department as well as director of the Minnesota Geological Survey from 1911 until his retirement in 1944. In addition, he had served as associate editor for the *Journal of Geology*.

E. W. Lindstrom, 57, head of the Genetics Department of Iowa State College as well as of the Genetics Section of the Agricultural Experiment Station, died November 8 in Ames.

A new method of seismic exploration to aid in locating underground petroleum reserves has recently been announced by the Institute of Inventive Research, San Antonio, Texas. It is expected that the new method, now being developed under the Institute's sponsorship by T. C. Poulter, associate director of the Stanford Research Institute and widely known geophysicist, will speed up the search for oil deposits by eliminating drilled

shot holes and at the same time greatly reduce exploration costs. In the Poulter procedure the charges in the explosive pattern are set on stakes in a hexagonal design close to the ground and exploded simultaneously, one of the charges being in the center. The shaped charges used are based on the "Munroe Effect," established by Prof. C. E. Munroe in 1888. Dr. Poulter first conceived the idea while conducting experiments in the Antarctic during the Byrd Expedition of 1933-35, on which he served as senior scientific adviser. The Poulter Method is reported to produce the same or, in many instances, better seismic records than present procedures and employs the identical seismic recording equipment now generally in use. This week's cover depicts a night explosion of a 13-charge detonation covering a 120-foot area.

The American Statistical Association, with offices at 1603 K Street, N.W., Washington, D. C., has announced the appointment of a Commission on Statistical Standards and Organization. The functions of the Commission will be to provide a tribunal to render opinions and recommendations on controversial issues relating to statistical procedure and presentation of statistical material, to develop a list of minimum standards for published statistical materials, and, upon request from governmental bodies, to review actual or proposed undertakings and make recommendations relative to standards.

Members of the new Commission include Lowell J. Reed, Johns Hopkins University, and Samuel S. Wilks, Princeton University (both for one-year terms); Isador Lubin, U. S. member of the Economic and Unemployment Commission, UN Economic and Social Council, and F. W. Notestein, Princeton University (two years); Frederick E. Croxton, Columbia University, and Walter A. Shewhart, Bell Telephone Laboratories (three years).

Excerpta Medica, the important new international abstracting service giving comprehensive coverage, in English, of the clinical and experimental medical fields, has announced that all sections of the service are now appearing regularly. At present, the

service is undergoing a reorganization as a foundation, in cooperation with the original Dutch publishing houses. The Chief Editorial Board which plans the general medical direction of *Excerpta Medica*, includes M. W. Woerdeman, fellow and secretary of the Royal Netherlands Academy of Science as well as professor of anatomy and embryology; A. P. A. de Kleyn, professor of otorhinolaryngology and also a fellow of the Royal Netherlands Academy of Science; and W. P. C. Zeeman, professor of oto-rhino-laryngology. At present over 4,000 specialists are cooperating in the work. The Williams & Wilkins Company of Baltimore, Maryland, is sole agent for the service in the U. S., Canada, and Central America.

The National Registry of Raw Chemicals, 35 West 33rd Street, Chicago 16, Illinois, recently announced that it is currently interested in obtaining: cyanin chloride; ketipic acid; gulose; fenchyl alcohol; propyl catechualdehyde butyl ether; 2-fluoroethyl bromide; lactic dehydrogenase; acetyl thiocholine chloride, bromide or iodide; 3,3,3-trichloropropionic acid; thiocarbonyl fluoride; sodium camphocarbonate; phosphorous trioxide; dimethyl strontium; diethyl bromo gold; cuprous fluoride; chlorotrifluorogermane; capsaicine; 1-naphthol-2,4-disulfonic acid; fluorogermane; and mesobilirubinogen.

Make Plans for—

American Mathematical Society, November 27, Los Angeles, California.

American Society of Mechanical Engineers, 69th annual meeting, November 28-December 3, Hotel Pennsylvania, New York City.

Conference on Electronic Instrumentation in Nucleonics and Medicine sponsored by the Institute of Radio Engineers and American Institute of Electrical Engineers, November 29-December 1, New York City.

American Medical Association, interim session, November 30-December 3, St. Louis, Missouri.

American Academy of Dental Medicine, annual midwinter meeting, December 5, Hotel Pennsylvania, New York City.